Irvine H. Johnson

TROPICAL SCIENCE

THE QUARTERLY JOURNAL
OF THE TROPICAL PRODUCTS INSTITUTE

Volume II · Number 3
1960

LONDON
HER MAJESTY'S STATIONERY OFFICE
PRICE 6*s.* NET

WILEY books

BIOCHEMISTRY OF PLANTS AND ANIMALS

by M. F. MALLETTE, *Associate Professor of Agricultural and Biological Chemistry*, P. M. ALTHOUSE, *Professor of Agricultural and Biological Chemistry*, and C. O. CLAGETT, *Professor of Agricultural and Biological Chemistry; all of The Pennsylvania State University.*

The authors offer the student an introduction to the field as a whole by providing a balanced, intergrated treatment of both plant and animal biochemistry.

568 Pages 68s. net

FOREST AND SHADE TREE ENTOMOLOGY

by R. F. ANDERSON, *School of Forestry, Duke University.*

A one-term upper division course in general forest entomology dealing with protecting forest and shade trees from insect attack.

432 Pages 66s. net

MILK PRODUCTION AND PROCESSING

by H. F. JUDKINS, *The American Dairy Science Association* and H. A. KEENER, *Professor of Dairy Science.*

The material contained in this book is broad enough to prepare the student for advanced work in dairy science.

452 Pages 64s. net

MARKETING POULTRY PRODUCTS

by E. W. BENJAMIN, Ph.D., *et al.*

It describes in detail the processes, techniques and economic factors involved in the movement of poultry, eggs, and their by-products from producer to consumer.

327 Pages *5th Edition* 62s. net

PRINCIPLES OF PLANT BREEDING

by R. W. ALLARD, *Professor of Agronomy.*

Contents: Introductory Topics; Genetics Basis of Breeding Self-Pollinated Crops; Breeding Methods with Self-Pollinating Crops; Genetics Basis of Breeding Cross-Pollinated Crops; Breeding Methods with Cross-Pollinated Crops; Breeding for Disease Resistance; Polyploidy in Plant Breeding; Interspecific Hybridization.

544 Pages *About 80s. net*

JOHN WILEY & SONS LTD.,

GORDON HOUSE, GREENCOAT PLACE, LONDON, S.W.1.

Tropical Science

The quarterly Journal
of The Tropical Products Institute
(*formerly the Colonial Products Laboratory*)

EDITOR:
R. H. KIRBY, B.Com., Ph.D.

ASSISTANT EDITOR:
Miss M. KERSHAW, B.Com.

1960
Volume II, Number 3

LONDON
HER MAJESTY'S STATIONERY OFFICE
1960

WILEY books

BIOCHEMISTRY OF PLANTS AND ANIMALS

by M. F. MALLETTE, *Associate Professor of Agricultural and Biological Chemistry*, P. M. ALTHOUSE, *Professor of Agricultural and Biological Chemistry*, and C. O. CLAGETT, *Professor of Agricultural and Biological Chemistry; all of The Pennsylvania State University.*

The authors offer the student an introduction to the field as a whole by providing a balanced, intergrated treatment of both plant and animal biochemistry.

568 Pages 68s. net

FOREST AND SHADE TREE ENTOMOLOGY

by R. F. ANDERSON, *School of Forestry, Duke University.*

A one-term upper division course in general forest entomology dealing with protecting forest and shade trees from insect attack.

432 Pages 66s. net

MILK PRODUCTION AND PROCESSING

by H. F. JUDKINS, *The American Dairy Science Association* and H. A. KEENER, *Professor of Dairy Science.*

The material contained in this book is broad enough to prepare the student for advanced work in dairy science.

452 Pages 64s. net

MARKETING POULTRY PRODUCTS

by E. W. BENJAMIN, Ph.D., *et al.*

It describes in detail the processes, techniques and economic factors involved in the movement of poultry, eggs, and their by-products from producer to consumer.

327 Pages *5th Edition* 62s. net

PRINCIPLES OF PLANT BREEDING

by R. W. ALLARD, *Professor of Agronomy.*

Contents: Introductory Topics: Genetics Basis of Breeding Self-Pollinated Crops; Breeding Methods with Self-Pollinating Crops; Genetics Basis of Breeding Cross-Pollinated Crops; Breeding Methods with Cross-Pollinated Crops; Breeding for Disease Resistance; Polyploidy in Plant Breeding; Interspecific Hybridization.

544 Pages *About 80s. net*

JOHN WILEY & SONS LTD.,

GORDON HOUSE, GREENCOAT PLACE, LONDON, S.W.1.

Tropical Science

The quarterly Journal
of The Tropical Products Institute
(*formerly the Colonial Products Laboratory*)

EDITOR:
R. H. KIRBY, B.Com., Ph.D.

ASSISTANT EDITOR:
Miss M. KERSHAW, B.Com.

1960
Volume II, Number 3

LONDON
HER MAJESTY'S STATIONERY OFFICE
1960

This journal is successor to *Colonial Plant and Animal Products*. Any inquiries concerning articles, etc., in this journal should be addressed to The Editor, Tropical Products Institute, 56-62 Gray's Inn Road, London, W C.1

VOLUME II . NUMBER 3 . 1960

Contents

Articles

page

A Study of Grain Storage in Fossae in Malta
By Mary B. Hyde, *Pest Infestation Laboratory*, and C. G. Daubney, *Department of Trade and Industry*, Valletta . . 115

The Control of Insects Infesting Groundnuts After Harvest in the Gambia: III. The Effect of Decortication on the Infestation of Groundnuts by *Tribolium Castaneum* (Hbst) and other Insects
By A. A. Green, *Pest Infestation Laboratory* 130

The Control of Insects Infesting Groundnuts After Harvest in the Gambia: IV. The Practical Application of Control Measures
By T. Rhynehart, *Department of Agriculture, The Gambia*. . 134

The Production of Hardboard from Tropical Timbers: VI. Kapur (*Dryobalanops* spp.), Keruing (*Dipterocarpus* spp.), Red Seraya (*Shorea* spp.), and White Seraya (*Parashorea Plicata*)
By D. F. Packman, *Forest Products Research Laboratory* . . 140

A Review of the Market and World Trade in Bananas
By Mrs. D. E. Kay and E. H. G. Smith 154

Notes

Spontaneous Heating and Combustion of Oilseed and Oilcake 166

Sudan Jutes 167

Book Reviews. 168

Bibliography 173

A Study of Grain Storage in Fossae in Malta

By Mary B. Hyde and C. G. Daubney
Pest Infestation Laboratory, Agricultural Research Council
and
Standards Laboratory, Department of Trade and Industry, Valletta

Summary

The method of storing grain in underground fossae in Malta is described. A test, in which a pit was experimentally treated with a lining of bitumen, showed that such treatment was satisfactory, both from the water-proofing point of view, and also as a means of dispensing with the traditional straw lining.

Introduction

Underground storage of grain in pits has been used from time immemorial in certain countries, particularly those in the Middle East and central Mediterranean region. In Malta such storage has been in underground chambers known as granaries or fossae, which in the course of time have become defective and no longer efficient as storage containers.

In an attempt to improve the position, an experimental treatment was given to one of the fossae; this treatment was evolved by the Malta Public Works Department with the help of the Building Research Station, Department of Scientific and Industrial Research. The present paper describes the results of a storage experiment in this pit, against the general background of fossa storage in Malta.

History and Construction of the Fossae

The underground granaries of Malta were constructed by the Knights of St. John under the Grand Magistracy of de Redin (1657-1660), and are thus almost exactly three hundred years old. They consist of underground flask-shaped chambers (fossae) with narrow cylindrical necks, hollowed out of the solid globigerina limestone rock. A typical shape is shown in Fig. 1. There are in existence about two hundred individual fossae, ranging in capacity from 50 tons to as much as 500 tons. Many are damaged. Those at St. Publius Square, Floriana (Plate I), at Fort St. Elmo, Valletta (Plate II), and the Capuchin granaries are still in use and store the bulk of the Island's supply of grain.

The smaller chambers are 14 to 15 ft. in diameter and about 30 ft. deep, including the neck, which is about 3 ft. wide and 8 ft. long. The observations in this paper are based on this type. The necks are faced with shaped limestone blocks. The upper openings are closed by flat stone discs about 4 ft. in diameter (Plate II).

It is believed that in earlier times the limestone walls of each fossa were lined with a layer of a reddish-brown glazed cement-like substance

(pozzolana) which made them reasonably waterproof and more or less airtight. A few patches are still to be seen in the neck region of some of the fossae.

At the base of each fossa is a layer of compacted earth covering a perforated stone floor, below which lies a drainage pit. Although in the past considered necessary for drainage purposes, especially when the walls were washed down on cleaning, these sumps are a weakness in the design as they can render the chambers damp and also act as harbourages for insects.

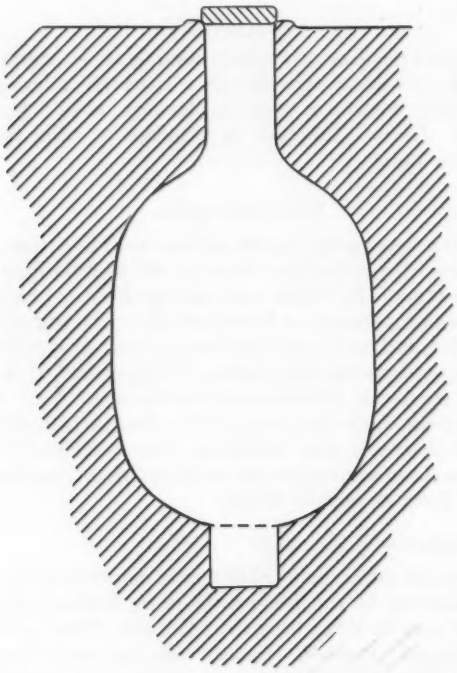


FIG 1. Section of typical fossa, showing stone cover, neck, storage chamber and position of drainage pit

Over the years the walls of the fossae became damaged and cracks developed, some extending up to 6 ft. into the limestone rock. This structural damage was accelerated by bombing during the 1939-45 war, and possibly also by vibration from modern heavy traffic. The fossae were therefore no longer waterproof and airtight, and grain stored in them deteriorated. About 1949/1950 the cracks were made good and the fossae walls rendered with cement. Although the pits are never wet in the sense that liquid water seeps in at the sides or up from the bottom,

there are damp patches on the walls, due either to condensation or to water percolating through the rock.

The present practice, and presumably that also in the past[1] is to absorb this moisture by lining the pits with straw as the grain is put in, so preventing the grain itself from coming into contact with the damp walls or bottom of the pit. Some authorities, however[2] considered that the presence of a certain amount of moisture was beneficial, and that when it was excluded the grain became damaged.

Principles of Airtight Storage

The safe storage of grain in the fossae is undoubtedly related to their effectiveness as airtight containers. The principle of airtight storage[3] is that, provided air is excluded, the oxygen present initially in the intergranular air will be used up and replaced by carbon dioxide. When the oxygen concentration has fallen to a sufficiently low level, or the carbon dioxide increased sufficiently, the respiration of the insects or moulds in infested or damp grain will be suppressed and the organisms mainly responsible for deterioration will die or become inactive before they have become numerous enough to cause commercial damage. If the container is completely airtight, no more insect damage will ensue; if air can still enter, even slowly, deterioration will gradually proceed.

If the grain remains reasonably dry, it can be kept safely under airtight conditions for long periods[4]. If it is very damp, however, changes can still take place, even in a completely hermetic container, which will make the grain unsuitable for milling and its viability will be affected[5,6]. It is generally accepted that the maximum safe moisture content for airtight storage is 13 to 13·5 per cent. for warm climates, and a little higher for cooler countries. If the moisture content is higher than this originally, or becomes so due to entry of water (liquid or vapour) into the storage container, the grain can become damaged. If oxygen can also enter owing to incomplete airtightness, moulds will develop and seriously affect the grain.

There is however no need to doubt the accuracy of Jones'[2] statements about the need for slight dampness for safe storage in fossae. It may be necessary to recall that in those days the stored grain was doubtless grown in nearby countries rather than in Australia or America. If the bulk of the grain were really dry, it is possible that the moisture from the walls was largely absorbed by the outer layers of wheat, as it is by the straw lining today. The intergranular oxygen was presumably reduced by the very rapid respiration of this damp layer and hence the remainder of the grain was undamaged by insects or moulds.

Present Arrangements in Malta

At the present time, wheat is normally stored in the fossae for periods of six to nine months. Grain, with a moisture content of about 12 per cent., although sometimes damper, is imported mainly from Canada and Australia throughout the year, and the fossae are filled and emptied more or less in rotation or according to blending requirements. In wet weather precautions are taken during handling to ensure that the wheat is kept as dry as possible.

The individual fossae vary considerably in their efficiency as safe storage containers. In some instances an appreciable proportion of the grain becomes mouldy or otherwise damaged and has to be sold as animal feed; in others, the damage is less extensive. The affected areas of the grain are usually at the bottom and at the surface, just below the base of the neck. It would seem that the deterioration is probably due to moisture rising from the sump or entering through the not completely water-tight cement seal round the covering stone. To a lesser extent there may be permeation through the walls, or along cracks.

The Present Experiment

The object of the present experiment was primarily to test the effectiveness of a waterproofing treatment given to one of the fossae in an attempt to make it a safe storage container, and to compare this fossa with an untreated one, over a normal period of storage, i.e. about six months. As well as investigating the effectiveness of the treatment as a barrier to liquid water and water vapour, it was hoped to study its efficiency in making the fossa airtight and hence in preventing insect attack, and mould growth if by any chance it became damp. A subsidiary object was to dispense with the straw lining.

The behaviour of the grain during storage was followed by measuring temperature changes in the grain and analyzing the intergranular air for oxygen and carbon dioxide; changes in temperature and in the concentrations of these gases might be expected if the grain was infested by insects, or was of a high moisture content either initially or through subsequent entry of moisture.

Two fossae (Nos. 42 and 43) on the St. Publius site at Floriana were used for the experiment, each holding about 60 tons of grain. No. 42 was left untreated, and filled with grain to the base of the neck, in the normal way, using straw for lining. No. 43 was given a waterproofing treatment and filled with grain to the top of the neck, without straw being used.

Treatment of the Fossa Walls

The treatment consisted of applying to the inside walls, on a preliminary cement rendering, four coats of an aqueous bitumen emulsion, with a layer of glass-fibre mesh between the second and third coats of bitumen. In the present instance, a 'Flintkote' emulsion was used, and 'Tyglas' fabric for the glass-fibre mesh. Such a treatment is the standard waterproofing treatment used by the Malta Public Works Department for flat roofs of buildings. Because of the confined space, it was obviously not possible to use hot bitumen, or bitumen in a volatile and toxic solvent, inside the fossa. A cold bitumen emulsion had therefore to be used, although known to be a less efficient barrier to gases.

After the last layer of bitumen had dried, a cement rendering $\frac{1}{4}$ to $\frac{1}{2}$ inch thick was put on, to form a hard surface to protect the bitumen from abrasion by wear and tear, and to prevent the grain from sticking to it.

PLATE I. The Floriana granaries. General view, showing rows of fossae with stone covers. (Note structure for housing testing equipment to the right of the experimental fossa in the foreground)

[facing page 118

facing page 119]

PLATE II. The St. Elmo granaries. General view, showing empty fossa in foreground, with loose cover and full fossae behind, with sealed covers

The treatment was applied to the whole of the flask-shaped portion of the fossa and carried right up to the top of the neck. Before the waterproofing treatment was applied, the sump below the storage chamber was sealed off by cement, so that the waterproofing layer was continuous over the whole of the fossa. This work was completed about three months before filling.

Although the horizontal surface of the cover was not treated with bitumen, it was planned to seal it with a coat of bitumen emulsion over the cement filling (Plate I, fossa in foreground). In fact the sealing on of the cover was not carried out as thoroughly as intended, and this caused slight damage to the grain at the top.

Condition of the Fossae when Empty

The condition of the two fossae was carefully noted before they were filled with grain (at the end of November 1958).

The cement-rendered walls of the treated fossa (No. 43) were smooth and for the most part dry, except near the base, where some water had collected at the bottom, either by condensation or from rain water.

The walls of the untreated fossa (No. 42) had been left untouched after the previous emptying. There was damp and mouldy straw adhering to much of the moist wall surface, particularly in the lower half, and a number of live cockroaches (*Periplaneta americana*) and woodlice were seen near the base. All the straw was therefore scraped off, and the fossa treated with an insecticidal smoke containing lindane, before it was filled with grain for the experiment.

The air in both fossae was warm and very damp, as shown by the following measurements (taken by whirling hygrometer), 6 ft. from the bottom:

Fossa	*Temperature* (°C.)	*Relative Humidity* (%)
42	21·1	96
43	21·7	89·5

Much of this warm air would be displaced as the grain was put in, however, and the moisture in the remainder would be absorbed by the large mass of wheat with negligible increase in grain moisture content.

The Grain Used

The grain was No. 1 (Dark) Northern Spring Wheat, shipped from Baltimore, U.S.A. in November 1958. It was of somewhat lower grade than is normally bought. It had no obvious signs of insect infestation, nor was any infestation detectable by a breeding-out test carried out in the laboratory on a 2-kg. sample. Its average moisture content, determined by oven drying at 113°C. for four hours in a ventilated oven, was 13·0 per cent. in the treated fossa (No. 43) and 12·9 per cent. in the untreated one (No. 42). In this connexion it should be mentioned that the weather at the time of filling was very unsettled and that the operation extended over two days for each fossa.

Methods

The Air in the Fossae

Before filling with grain, thermocouple wires were installed for measuring temperature at the centre of the fossa and at the base of the neck, and tubes were inserted for sampling the intergranular air at the bottom, the centre and at the base of the neck.

The temperatures were read to an accuracy of $\pm 0{\cdot}3$°C. by means of a Doran 'Mini' potentiometer. The air was analyzed for oxygen and carbon dioxide by 'Fyrite' air analyzing apparatus, which has an accuracy of about $\pm 0{\cdot}5$° per cent. by volume.

The Grain

Examination of the grain at the beginning and end of the experiment was supplemented by determination of moisture content and germination, and by chemical analysis for protein, free fatty acid and reducing and non-reducing sugars. In certain instances, mycological examination was made on the grain at the end of the test. The methods employed were those currently in use at the Pest Infestation Laboratory.

Results

State of the Grain when Fossed

The results of the Laboratory tests on the grain on fossing are given in the table (page 129). Visual examination showed that the grain was normal in appearance. It had no abnormal smell or taste. There was no sign of visible mould growth. The grain was apparently free of gross insect infestation, although one live adult of the Lesser Grain Borer (*Rhyzopertha dominica*) was sieved out during the fifth week of examination in a breeding out test which extended for eleven weeks.

The moisture content of the grain, which arrived, bagged, in five-ton lorries, ranged from 12·7 per cent. to 13·7 per cent., with averages of 13·0 per cent. and 12·9 per cent. for Fossa 43 and 42 respectively. Thus there were some pockets of grain above 13·5 per cent., which is near the maximum for safe storage under hermetic conditions in hot countries.

The average germination of the grain was 89 per cent., and the germinative energy was reasonably good.

The results of the chemical analysis indicate that although the free fatty acid was slightly high and the protein a little low for high quality bread grain, the wheat was still sound and there was no indication that it was unsuitable for storage.

It was obvious that the grain was somewhat mixed in quality. Some of the samples contained more vitreous grains than others, and it is likely that the protein content, in particular, was rather variable.

Thus from the state of the grain when fossed it seemed clear that the experiment would not develop as a problem of the control of insect infestation, but as one of keeping grain of maximum moisture content for safe storage.

Observations during Storage

Temperature

The temperature in the main mass of grain did not change appreciably in either fossa (Fig. 2), indicating that there was no sign of 'heating'. The fall in temperature of the grain in the neck of the treated fossa (No. 43) agreed almost exactly with the fall in temperature of the air with the onset of winter. The untreated fossa (No. 42) did not show a like fall in temperature in the neck, due undoubtedly to the blanketing effect of the straw.

Composition of the Intergranular Air

Both fossae showed (Figs. 3 and 4) a reduction in the amount of oxygen in the intergranular air, the fall beginning later and being slower in the treated fossa (No. 43) than in the untreated one (No. 42). In the former, the concentration of oxygen at the bottom was reduced virtually to zero within six weeks, in comparison with three weeks for fossa 42. In the treated fossa, however, the oxygen at the centre also reached zero after about six weeks, although in the neck region it was never completely eliminated but varied between 1 per cent. and 4 per cent. In the untreated fossa (No. 42) only the bottom was oxygen-free, the concentration at the centre and at the base of the neck generally varying between 2 per cent. and 7 per cent.

This showed that neither of the fossae was completely airtight, and also that some of the grain (or straw) had become moist enough to have a fairly high rate of respiration.

In a normal process of respiration, oxygen is replaced as it is consumed by an equal volume, or nearly so, of carbon dioxide. No carbon dioxide was detected inside fossa 43 during the entire experiment. This is due to its having been absorbed chemically by the free lime in the new cement rendering of the wall. In the untreated fossa, with the old cement rendering on the walls, the concentration of carbon dioxide increased progressively and at first rapidly (Fig. 4). After all the oxygen was used up, there was a further, slower production of carbon dioxide, obviously due to the respiration of anaerobic organisms in the presumably damp grain or straw.

Observations on and after Opening

The Fossae—Treated Fossa:

The walls were mainly sound and dry, although the sealing of the cover had not been completely adequate, and there had been some entry of water at the top, resulting in discoloration of the upper part of the wall of the neck. This moisture was undoubtedly rain water from the fairly frequent heavy showers in the early part of the storage period.

A number of fine shrinkage cracks had developed in the cement rendering of the fossa walls, particularly in the 'shoulder' region, below the neck. Since no signs of dampness or discoloration were seen in the neighbourhood of these cracks, it can be assumed they did not penetrate into the bitumen layer.

The air in this fossa had no abnormal smell.

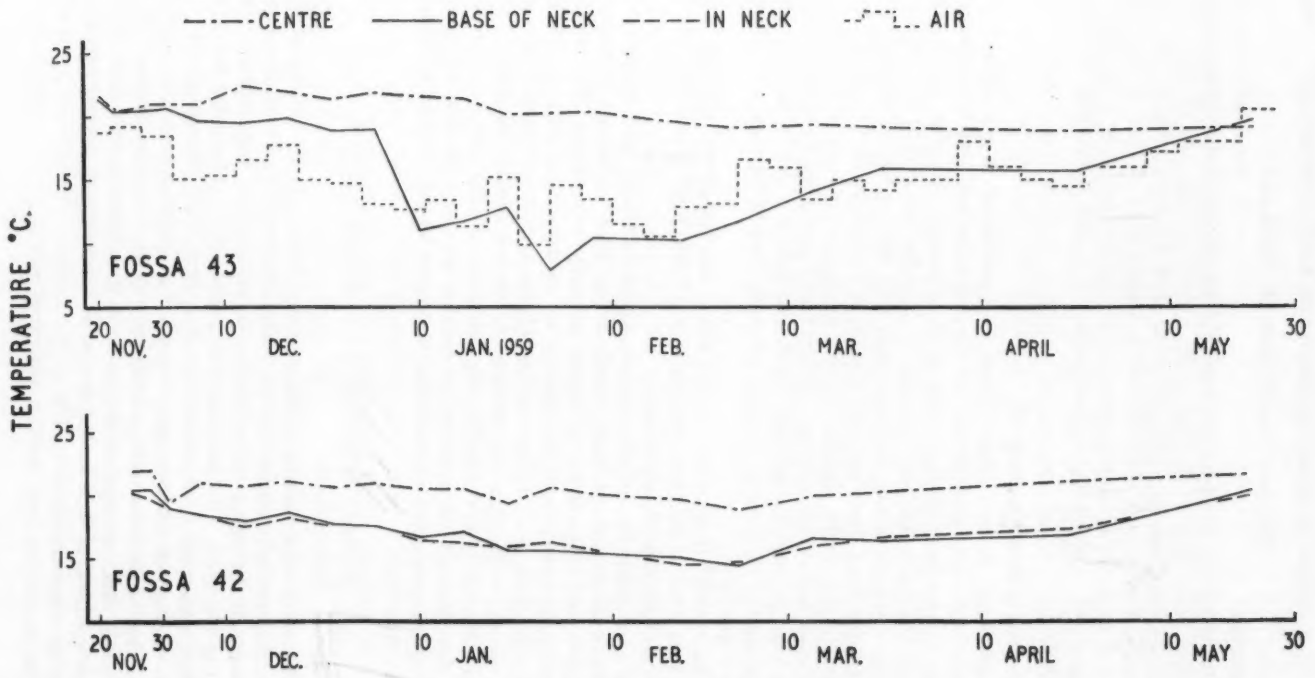


FIG. 2. Temperature changes in fossae 42 and 43

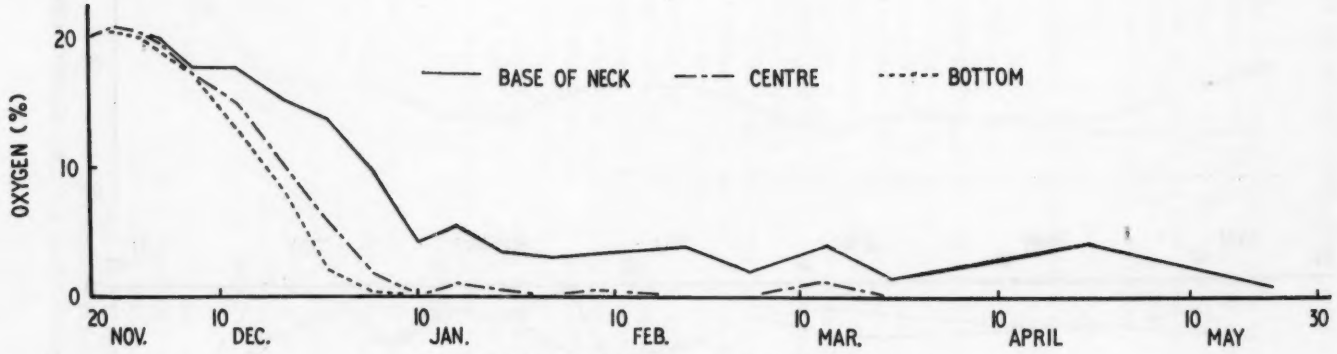


FIG. 3. Concentrations of oxygen in treated fossa 43

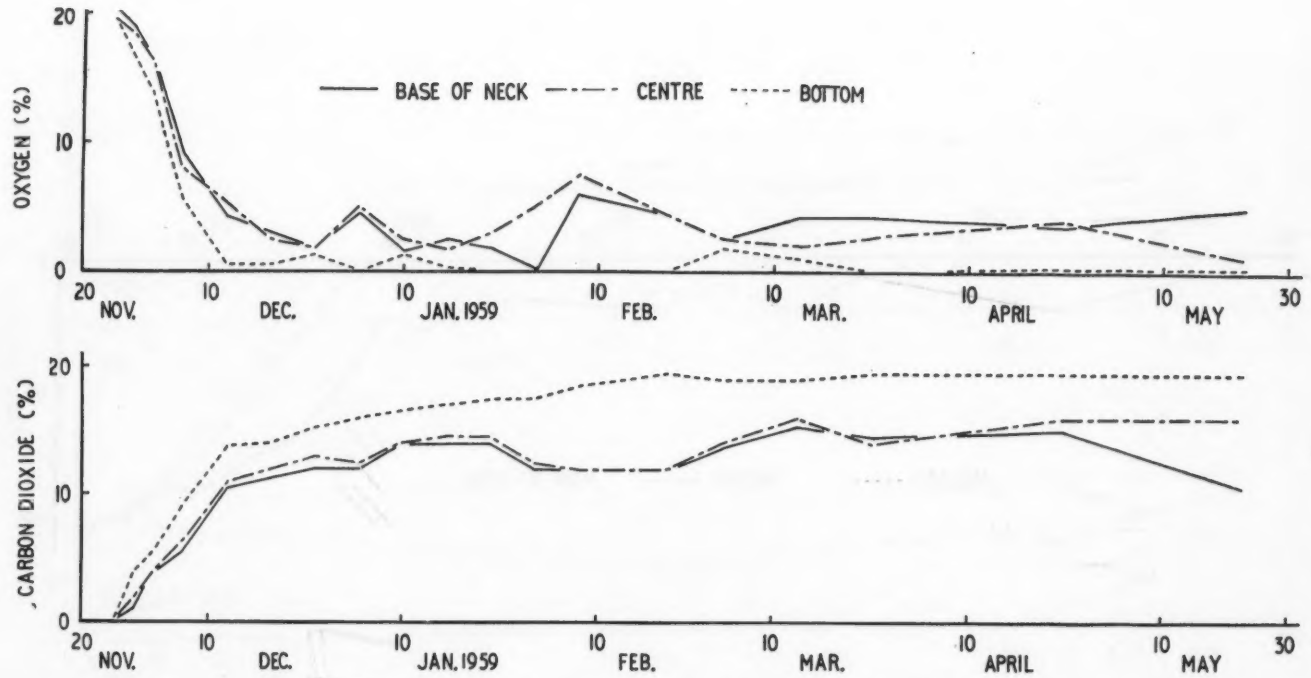


FIG. 4. Concentrations of oxygen and carbon dioxide in untreated fossa 42

Untreated Fossa:

The state of this fossa (No. 42) was very similar to or even worse than that before cleaning prior to filling. The neck was clean and dry, but straw was adhering to the walls in the lower half of the fossa, associated with brown mould, and, nearer the base, there were very large areas of white fungal growth. The air in this fossa had a very strong smell of over-ripe cheese, even after artificial ventilation.

The Grain

There were interesting differences between the state of the grain in the two fossae.

Grain in Treated Fossa:

The grain at the surface showed some sign of mould growth, particularly that near the walls of the neck, but the amount affected was small. Live adults of the Granary Weevil (*Calandra granaria*) became apparent shortly after the lid was removed. These were confined to the top few inches of grain only, and no live insects were found lower down, where presumably the oxygen concentration was too low for them to survive. The weevils had apparently developed from an initial infestation too low in intensity to be detected by the breeding out test.

The main bulk of the grain was normal in appearance, and had no abnormal smell, although a few patches of grain remained caked to the wall, particularly in the shoulder region. Towards the base there was a quantity of slightly damper grain, about 1,500 kg., compacted on to the outwardly sloping walls. Although this grain could have been removed by the suction apparatus, it was left in the fossa for subsequent examination. It did not have any abnormal smell or show signs of visible mould. All the 68 tons of grain from this fossa were sent to the millers as undamaged. The increase in moisture content at the base (see table) was no doubt due to absorption of the water which had got in when the fossa was empty. A *t*-test showed that there was no statistical significance in the increase in the overall moisture content from the initial average of 13·0 per cent. on filling to the final average on emptying of 13·2 per cent.

There was some decrease in the viability of the grain in the lower part of this fossa (Sample 2 in table), which was unexpected in relation to the fairly low moisture content, and which must have been due to the removal of all oxygen from this region. The changes in free fatty acid, although appreciable, and the lesser changes in sugars, are not such as to indicate commercial damage. In view of the initial quality of the grain, the variation in the values obtained for protein is not regarded as significant.

A mycological examination of a sample of the main bulk of the grain gave mould counts such as would be expected from this type of grain (Sample 1 in table). In obviously mouldy grain taken from the top of this fossa there was, as expected, a high mould count, mainly of *Aspergillus* spp. Large numbers of mycelial yeasts were found in a patch of very damp grain from near the base of the neck. These also occurred in the

small quantity of damp grain at the bottom of the fossa. Experience at the Pest Infestation Laboratory indicates that mycelial yeasts are normally associated with storage of grain of high moisture content under nearly but not quite airtight conditions.

Grain in Untreated Fossa:

A large proportion of the grain in this fossa was sound and showed no signs of insects or of visible mould growth. Presumably the absence of insects at the surface was partly due to the accumulation of carbon dioxide, for the oxygen concentration was at least as high as in the treated pit, where a few live insects were present at the top, but where there was no carbon dioxide in the intergranular air. It is also possible that the grain in this fossa was from a different hold in the ship from that in fossa 43, and so may have been completely free of infestation when fossed.

After about 50 tons of grain had been removed, the wheat became softer, indicating higher moisture content (see table, Sample 5). It began to develop a slightly sour-sweet smell and taste, which increased progressively with depth, and which other experience can confirm as resulting from anaerobic fermentation when grain of high moisture content is stored in oxygen-free conditions. About 18 per cent. of the 61 tons of grain in this fossa was affected in this way.

Excluding this tainted grain towards the base (Sample 5), there was an overall increase in the moisture content of the apparently unaffected grain in the upper part of this fossa from an average of 12·9 per cent. on fossing to 13·4 per cent. on emptying; this increase is statistically significant at the 5 per cent. level. If the 11 tons of affected grain had been included, the total increase in grain moisture content would have been much greater, for the average moisture content for the whole fossa would have been about 14·2 per cent.

Of the chemical changes, the variation in protein is negligible. The increase in free fatty acid, although considerable, did not reach the figure of 40 which is normally regarded as unacceptable commercially. However, the increase in reducing sugars (to 9·4) coupled with the low figure for sucrose (19·7) are considered as indicating commercial damage.

Although most of the 11 tons of tainted grain in the lowest part of this fossa was sent for milling, the last half-ton of grain, with a moisture content of 20·0 per cent., was in fact discarded as unfit for this purpose.

Mycological examination of some of the samples from this fossa again showed a high count of mycelial yeasts. The count of micro-organisms in Sample 5, near the bottom, was much lower than would have been expected from the original grain, and was presumably due to the death of the fungi under very low oxygen tensions.

Conclusions

The main conclusion to be drawn from the experiment is that grain can be stored safely in a fossa without straw if the fossa walls have been suitably treated to make them waterproof and airtight.

In the present test there were certain adverse changes in a little of the

grain in the treated fossa, largely due to inadequate sealing of the lid, but the main bulk of the grain was in good condition after six months' storage, and all was sent to the millers as 'undamaged'.

Temperature measurements throughout the period of storage showed that there had been no rise in temperature in the grain. The concentration of oxygen in the intergranular air was reduced, as expected with grain with an initial moisture content of 13 per cent. and the possibility of slight entry of water through the lid, resulting in a little growth of mould in this region. There was no significant increase in moisture content in the main bulk of the grain. The carbon dioxide produced was absorbed chemically by the free lime in the new cement rendering of the walls. The viability and chemical properties of the grain were not unduly affected by the storage, bearing in mind the quality of the grain when fossed.

The lid was not sufficiently airtight to prevent enough oxygen entering to keep alive a few grain weevils at the surface of the grain, but the main bulk was free from insect infestation.

The condition of the fossa itself was sound at the end of the experiment, apart from a few fine shrinkage cracks in the rendering.

The untreated fossa used as a control and lined with straw in the usual way afforded an interesting contrast. Although most of the grain from this fossa was sent to the millers as 'undamaged', including about 10 tons which had a perceptible taint, a small amount, near the bottom, was considered 'damaged' and set aside for animal feed. The grain in this fossa showed, especially towards the base, an increase in moisture content which resulted in certain biological and chemical changes normally associated with storage at high moisture content under hermetic conditions. About 18 per cent. of the grain in this fossa was affected in this way. Although this damp grain was not visibly mouldy, the microflora found on it after storage indicated that it had been kept under conditions which were almost, but not completely, airtight.

The straw used for lining the walls and filling in the neck had obviously absorbed a good deal of moisture, thus preventing it reaching the grain. Its mouldy condition showed that it had also contributed to the reduction in oxygen and accumulation of carbon dioxide that occurred in spite of the incomplete airtightness of the walls.

Acknowledgements

We should like to express our appreciation to the many people who gave valuable advice and assistance in the conduct of this experiment, and whose names are too numerous to mention. We are particularly indebted to Mr. E. Caruana Montaldo of the Public Works Department, and Mr. S. Said and Mr. A. E. Price of the Department of Trade and Industry, Valletta. We are also grateful to Mr. G. Ayerst of the Pest Infestation Laboratory who carried out the mycological tests.

We wish to thank Mr. J. Borg, Mr. J. D. Campbell, Miss M. Keeping, Mr. S. W. Pixton and Miss G. Wickenden for assistance in the experimental work.

References

(1) de Boisgelin, L., *Ancient and Modern Malta*, London: G. and J. Robinson, 1804, **1**, 42.
(2) Jones, H. D., 'Memoranda and Details of the Mode of Building Houses, etc., in the Island of Malta', *Prof. Pap. Cps. R. Engrs*, 1842, **5**, 204.
(3) Hall, D. W. and Hyde, M. B., 'The Modern Method of Hermetic Storage', *Trop. Agriculture*, 1954, **31**, 149-60.
(4) Hyde, M. B., 'Underground Storage of Grain and its Effects on Grain Quality', *Ber. 2. Getreidetagung, Detmold*, 1958, 153-65.
(5) Oxley, T. A. and Hyde, M. B., 'Recent Experiments on the Hermetic Storage of Wheat', *Proc. 3. int. Bread Congr. Hamburg*, 1955, 179-82.
(6) Oxley, T. A. and Hyde, M. B., 'The Airtight Storage of Damp Grain', *Farm Mech.*, 1957, **9**, 473-74.

Results of Laboratory Tests on Grain before and after Storage in Fossae

	On Filling *Average*	On Emptying								
		Treated Fossa (No. 43)					Untreated Fossa (No. 42)			
		Top*	Base of Neck	Upper Half(1)	Lower Half(2)	Very Bottom*	Base of Neck	Upper Half(3)	Lower Half(4)	Near Bottom(5)
Moisture content (per cent.)	12·9	18·4—22·7†	13·9—14·7†	13·3	13·2	16·1—16·9†	14·1	13·5	13·3	15·7—20·0†
Germination (per cent.)	89	0—5	—	84	61	7	—	83	79	27
Protein (N × 5·7) (per cent.)	12·3	—	—	11·5	11·9	—	—	11·9	12·4	12·2
Free fatty acid (mg. KOH/100 g. grain)	18·4	—	—	25·2	30·9	—	—	24·9	25·0	31·4
Reducing sugars (Maltose) (mg./g.) grain	3·5	—	—	5·0	4·9	—	—	4·8	5·1	9·4
Non-reducing sugars (Sucrose) (mg./g. grain)	26·1	—	—	25·0	24·9	—	—	25·7	25·2	19·7
Microflora (Colonies/mg. grain)										
Aspergillus spp. unidentified fungi	—	2,650	300‡	23	—	10·5	—	520	—	0·20
Mycelial yeasts	—	0	6,400‡	0	—	31·5	—	35	—	0·30

* A very small quantity only, showing slight damage.
† Range of several small samples.
(1) to (5) Made up of a number of small samples, bulked to form one sample for each numeral.
‡ A small area of exceptionally wet grain in this region (M/C. 19·4 per cent.).
— = not determined; 0 = none present.

The Control of Insects Infesting Groundnuts after Harvest in the Gambia: III. The Effect of Decortication on the Infestation of Groundnuts by *Tribolium castaneum* (Hbst.) and other Insects

By A. A. Green

Pest Infestation Laboratory, Agricultural Research Council

Summary

The centralized decortication of groundnuts in the Gambia before export has not greatly reduced the period of storage in shell when the nuts are damaged by the Groundnut borer, *Caryedon gonagra* (F.), but has introduced, in addition, a period of storage after decortication when the kernels may be attacked by the Rust-red Flour beetle, *Tribolium castaneum* (Hbst.). Stacks of bagged nuts, containing only a few *T. castaneum* shortly after decortication, developed very heavy infestations during storage for 16 weeks. Insecticidal treatments to prevent cross-infestation will therefore be unavailing unless the nuts are first disinfested, e.g. by fumigation.

Introduction

Until 1955, serious insect damage to harvested groundnuts in the Gambia was largely confined to the infestation of undecorticated nuts by the Groundnut borer, *Caryedon gonagra* (F.) and control of this insect was the primary aim of the investigations previously reported[1,2]. It was known at that time, however, that a scheme was being developed for the decortication of the bulk of the exportable crop. This would result in the storage of bagged, decorticated nuts awaiting export and was likely to introduce new and additional infestation problems to the Gambia.

Previous records[3,4,5,6] show that decorticated groundnuts stored in West Africa are likely to become heavily infested with the Rust-red Flour beetle, *Tribolium castaneum* (Hbst.) and that the resultant damage to the nuts is considerable. Observations were made, therefore, on the distribution of insects likely to infest shelled groundnuts in the Gambia and some small investigations were carried out.

Survey

During the survey of *Caryedon* infestations[1], examinations were made of traders' stores, empty seccos and native foodstores and huts. These were widely dispersed and gave a general picture of stored-product infestations throughout the Gambia. In all districts sites were found containing groundnut debris heavily infested with *T. castaneum* and infested to varying extents with the Confused Flour Beetle, *Tribolium confusum*, J. du V; the

Merchant Grain beetle, *Oryzaephilus mercator* (Fauv.); the Rust-red Grain beetle, *Cryptolestes ferrugineus* (Steph.); and the Tropical Warehouse moth, *Ephestia cautella* (Wlk.). The Khapra beetle, *Trogoderma granarium*, Everts, a common pest of groundnuts in West Africa[4], was not found in the Gambia. It must be borne in mind, however, that this insect was able to cause a major infestation of Nigerian groundnuts in 1949 although its presence had not been detected during a survey in the previous year[7].

A small decorticating and oil-extracting mill which had been operating privately for several years was found to be very heavily infested with both *T. castaneum* and *C. ferrugineus*. An inspection at the beginning of the decorticating season showed heavy infestations in debris remaining from the previous season; a 1 lb. sample removed from a conveyor duct contained 225 *Tribolium* and 105 *Cryptolestes* beetles. Cross-infestation to some, at least, of the new season's crop was, therefore, certain to occur. Spread of insects was encouraged also by the practice of dumping vast quantities of waste material, mostly groundnut cortex with some edible waste, on surrounding land and in swamps. This material is able to support heavy infestations for at least several months after leaving the mill.

It was quite clear from this survey tha. the endemic populations of stored product insects were such as to threaten heavy infestations of any groundnuts stored in the Gambia after decortication.

Investigation

Infestation by *T. castaneum* of undecorticated groundnuts is very slight since the beetle can effect entry only if the cortex of the nut has been damaged. An examination in the field revealed no insects in freshly decorticated nuts from a clean machine operated out of doors. It was decided, therefore, to use these nuts for some small-scale trials to compare various methods for preventing the cross-infestation of bagged groundnuts after decortication. Protective treatments included the application of insecticides to the outside of sacks, the use of various types of lined sacks, and the covering of stacks of bagged nuts with protective sheeting.

During the 16 weeks of storage, however, heavy infestations developed under all conditions of test. Although the 8,176 lb. of groundnuts used had first passed over the coarse sieves of the decorticating machine and were relatively clean and dust-free, they contained at the end of the trial 208 lb. (2·5 per cent.) of insects, frass and debris able to pass a 10-mesh sieve. It was estimated from weighed and counted samples that some sacks contained at least 90,000-100,000 insects. Of the insects present, about 70 per cent. were *Tribolium* spp., mainly *T. castaneum* but including a few *T. confusum;* about 22 per cent. were *O. mercator* and about 8 per cent. were *C. ferrugineus*.

Equally heavy infestations developed in all bags including those where mechanical barriers had greatly reduced the likelihood of cross-infestation. It appeared, therefore, that the infestations in the bags must have developed largely from a small number of insects present in the nuts at the time of decortication but remaining undetected by the field sampling technique.

The trials demonstrated clearly that heavy infestations of insects developed rapidly on groundnuts stored in the Gambia after decortication and that measures designed to prevent cross-infestation were likely to have negligible effect unless the small infestation present in newly-decorticated nuts could first be controlled.

It followed, therefore, that the nuts would need to be fumigated unless they could be exported very soon after decortication. It was decided that the industry could not at that time afford the costs of fumigating all groundnuts before export and that an effort should be made, by means of rotational storage and shipment, to reduce to an acceptable period the delay between decortication and export. To this end the Gambia Oilseeds Marketing Board introduced an excellent scheme in the 1955/56 season at Kuntaur, bagged nuts being stored in large, ridged stacks (Plate I) each containing about 11,000 bags, about three stacks comprising a normal ship-load. The oldest stacks were shipped first and no heavy infestations occurred. No comparable schemes were followed at the other mills and vast stacks were built (Plate II) so that some nuts were stored for as long as five months and became extremely heavily infested with *T. castaneum*.

Discussion and Conclusions

The introduction into the Gambian groundnut industry of full-scale decortication has resulted in an increased liability to insect attack. While only partially reducing the period of exposure of the unshelled nuts to attack by *C. gonagra*, it has introduced a period of storage after decortication during which serious losses can occur from damage by *T. castaneum* and, to a lesser extent by *T. confusum*, *O. mercator* and *C. ferrugineus*. These infestations can develop inside the sacks from the very small number of insects present at the time of decortication or, since all the species involved occur commonly throughout the Gambia, by cross-infestation at any time after decortication.

Although rapid shipment after decortication greatly reduces the problem, it is obviously desirable that the crop should be entirely free from infestation when exported. The risk of cross-infestation could be reduced considerably by improving the standards of hygiene at stores and mills. Bagged, decorticated groundnuts could be protected by spraying the outside of the stacks with a suitable contact insecticide; Green and Kane[8] have shown that malathion holds promise for this purpose. No good will be served by protective spraying, however, unless the nuts are first rendered free from infestation, either by fumigation or, possibly, by the admixture of an insecticide having residual toxicity. Work on the latter is proceeding.

These observations demonstrate how easily a change in industrial practice can lead to new problems of food storage.

Acknowledgements

In addition to the acknowledgements made in earlier papers of this series I should like to thank my colleagues, Miss M. J. Kane and Miss P. M.

[facing page 132]

PLATE I. System of stacking bagged groundnuts for shipment in rotation according to period of storage

facing page 133

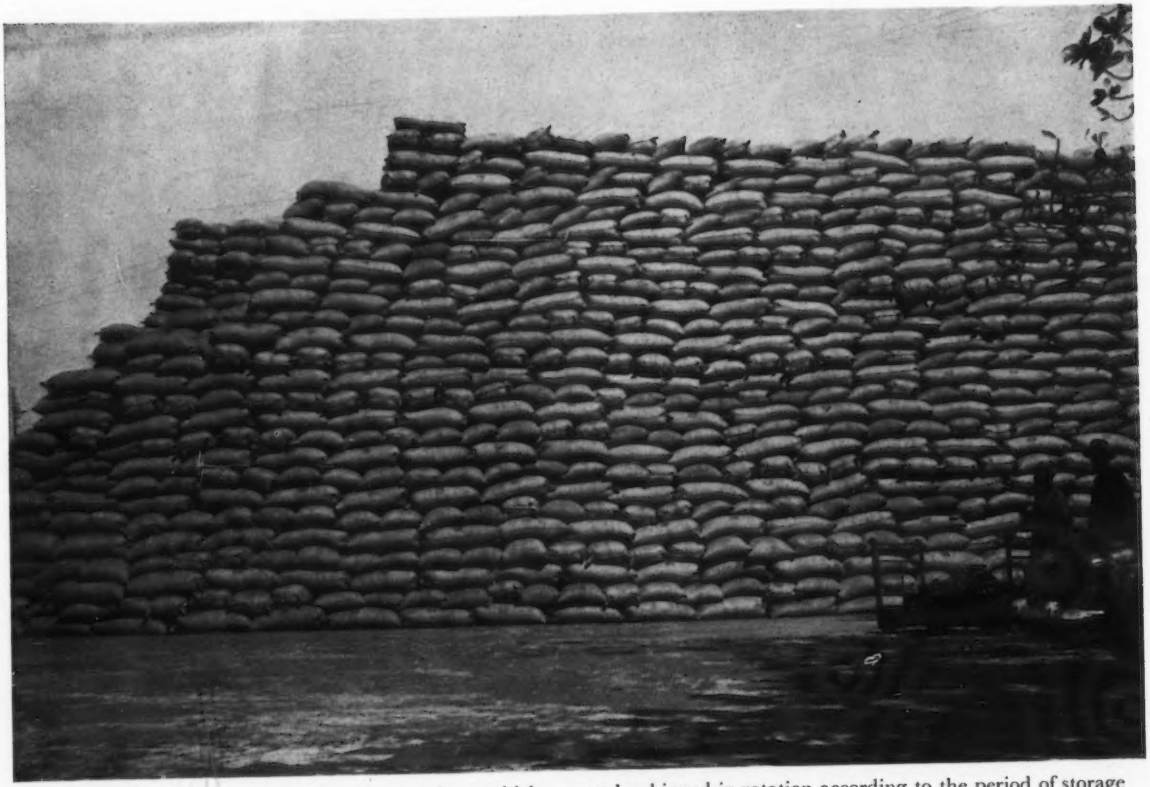


PLATE II. A large stack of bagged groundnuts which cannot be shipped in rotation according to the period of storage

Davey, who painstakingly undertook the tedious examination of large numbers of samples and insects.

References

(1) Green, A. A., 'The control of insects infesting groundnuts after harvest in the Gambia. I. A study of the Groundnut borer, *Caryedon gonagra* (F.) under field conditions'. *Trop. Sci.*, 1959, **I,** No. 3, 200.

(2) Green, A. A., 'The control of insects infesting groundnuts after harvest in the Gambia. II. Field trials on the control of the Groundnut borer, *Caryedon gonagra* (F.)'. *Trop. Sci.* 1960, **II,** Nos. 1 and 2, 44.

(3) Fairchild, Miss P. L. K., Raymond, W. D. and Spickett, R. G. W., 'Insect infestation of West African groundnuts'. *Colon. Pl. Anim. Prod.*, 1954, **IV,** No. 4, 330.

(4) Howe, R. W., 'Entomological problems of food storage in Northern Nigeria'. *Bull. ent. Res.*, 1952, **43,** 111.

(5) Howe, R. W., Hayward, L. A. W. and Cotterell, G. S., 'Control measures in 1948-50 against insects attacking groundnuts stored at Kano, Northern Nigeria'. *Bull. ent. Res.*, 1952, **43,** 259.

(6) Cotterell, G. S., 'The insects associated with export produce in Southern Nigeria'. *Bull. ent. Res.*, 1952, **43,** 145.

(7) Cotterell, G. S. and Howe, R. W., 'Insect infestation of stored food products in Nigeria'. *Colon. Res. Publ.*, No. 12, 1952. (London: H. M. Stationery Office.)

(8) Green, A. A. and Kane, Joyce, 'A comparison of lindane, DDT and malathion for the protection of bagged groundnuts from infestation by *Tribolium castaneum* (Hbst.)'. *Trop. Sci.*, 1959, **I,** No. 4, 290.

The Control of Insects Infesting Groundnuts after Harvest in the Gambia: IV. The Practical Application of Control Measures

By T. Rhynehart

Pest Control Officer, Department of Agriculture, The Gambia

Introduction

Since 1955, the Gambian Government has maintained a programme based on the findings of Green [1, 2, 3] for the control of insects infesting groundnuts after harvest. The present paper is concerned with measures taken to implement the recommendations of Green (whose concluding article in this series appears on pages 130-33), and with observations made on the practical problems involved.

The author was appointed as Pest Control Officer in February, 1957, and has since been concerned with the development and administration of a scheme for the insecticidal treatment of nuts intended for seed and for the supervision of all measures for the protection of groundnuts from insect attack in the Gambia.

There are two organizations responsible for the protection of Gambian groundnuts: the Gambia Oilseeds Marketing Board (G.O.M.B.), a quasi-government organization, and the Department of Agriculture. G.O.M.B., through licensed buying agents and their traders, purchases the entire exportable crop of groundnuts. It buys 0·5 per cent. lindane dust, distributes it to the traders, and directs them as to its correct use.

Until 1956 G.O.M.B. was wholly responsible for the administration of the seed nut scheme described by Hall[4] and for treatment of seednuts with insecticide. The farmer is now, however, encouraged to keep his own seed under a five-year plan during which the amount of seed stored and issued by the Board is being reduced. The scheme is now entering its fourth year and seed issues have fallen from about 6,000 tons to about 2,000 tons.

Although it is the Government's intention to introduce legislation, there has, up to 1960, been no legal requirement for the insecticidal treatment of groundnuts or of premises connected with the groundnut industry. G.O.M.B. can, however, penalise a trader for non-compliance with its instructions, since it licenses the traders and has the power to revoke a licence.

The Department of Agriculture has an overall responsibility for the insect control measures operated by G.O.M.B. and direct responsibility for the measures followed by the farmers. The Department makes a free issue to farmers of lindane dust for admixture with seed, and demonstrates techniques.

Control of the Groundnut Borer, *Caryedon gonagra* (F.)

Trade Nuts

During the latter half of the 1956-57 trade season visits were made to buying stations in the Protectorate to determine the extent to which Green's recommendations were being put into practice, and to assess the degree of insect control achieved.

It was soon evident that in general the dusting with lindane of the groundnuts held by traders was extremely haphazard. There was little apparent attempt to follow the dosage rate and frequency of application which had been recommended. Hygiene in traders' seccos was mainly poor, screenings and piles of infested, empty bags being stacked close to the stored groundnuts. All heaps of groundnuts seen were infested with the Groundnut borer, *Caryedon gonagra* (F.), although, in the few cases where the trader had attempted to use lindane correctly, such infestation was light. In one or two seccos which were inspected in May after all the groundnuts had been despatched for shelling, the ground was literally teeming with *Caryedon* adults.

The brief survey made in 1957 indicated that strictly enforced instructions were required and, at the instigation of the Director of Agriculture, G.O.M.B. circulated to all concerned detailed instructions regarding the use of lindane. Traders were warned that non-compliance with instructions could lead to disciplinary action being taken.

During the 1957/58 trade season, every buying station in the country was inspected and the overall control of *Caryedon* found to be appreciably improved. The issue of lindane was still inadequate, however, and some serious infestations developed, particularly in the more remote areas. Rates of dosage varied considerably largely because the authorities had not issued a simple instruction which could be understood locally but had passed directly to the traders the instruction to apply lindane dust at the rate of 1 lb. per 100 sq. ft. of secco surface. Furthermore, it was apparent that the surface of the heaps was disturbed by collection and delivery of nuts more frequently than had been anticipated by Green.[2]

It was recommended therefore that traders should be instructed to treat all seccos twice weekly with a very light surface dusting. This generally resulted in a twice weekly application at the approximate rate of 1 lb. per 100 sq. ft. The increased frequency of treatment resulted in considerably higher doses but it was estimated that, even under extreme conditions, the ultimate contamination of groundnut kernels would be negligible. For instance, if a small secco of about 450 tons should be conscientiously treated twice weekly for four months at the rate of 1 lb. per 100 sq. ft. of surface area, the total dose of lindane would be less than 20 parts per million. Using undecorticated groundnuts treated at the rate of 20 parts per million, Green[2] found that only 0·4 parts per million remained on the kernels after decortication.

During the 1958/59 trade season, visits to traders' seccos showed that there had been a noticeable response to instructions issued by G.O.M.B., helped no doubt by some traders having been penalised during the previous season. Lindane application was generally satisfactory and

supplies were better. As a result the degree of *Caryedon* infestation had been further reduced, the only heavy infestations being directly attributable to incorrect or insufficient treatment. Samples of unshelled nuts from all parts of the country were received throughout the season for free fatty acid estimation at the laboratory of Yundum Experimental Farm. Opportunity was taken to check them for evidence of *Caryedon* attack and it was gratifying to find that, of over four hundred samples, only the last one, in early May, showed evidence of *Caryedon* damage.

Observations since 1957 have shown that where heaps of unshelled groundnuts are treated with 0·5 per cent. lindane dust, at the rates recommended by Green, the degree of infestation by *Caryedon* is reduced to a level where it no longer constitutes a serious economic factor. The trader has little enthusiasm for control measures, since there is no monetary incentive, and it is unfortunate that the most serious stage of attack occurs at the trading stations. Legal powers of enforcement, or a greater exercise of G.O.M.B. disciplinary action are required.

Seed Nuts

Following Green's[2] recommendations for the treatment of seed with lindane dust, the Director of Agriculture organized demonstrations at the village level. These demonstrations emphasized the need for selection of good seed and showed the correct method of admixture of lindane dust. It was obvious in 1957 that where the instructions had been followed correctly, the seed had stored well with no damage. There were, however, complaints from some farmers that seed had been attacked even though lindane had been applied but investigation showed that oviposition had occurred before the seed had been treated. Treatment of the cortex had not, of course, prevented either the development of larvae within the nut or the emergence of some adults.

As a result of these observations it was felt desirable to give talks and demonstrations to the assembled Chiefs and village heads at the Divisional conferences in November 1957. At each of the four conferences the habits and life history of *C. gonagra* were outlined in simple terms and a demonstration experiment was set up. Two bags of sound groundnuts were taken, the contents of one being treated with lindane dust at the recommended rate and the other being left untreated. Both bags were then 'innoculated' with a culture of *C. gonagra*, sealed and left in the safe-keeping of the Divisional Commissioner to be opened at the next years' conference. The need for early selection of seed and treatment with lindane were emphasized.

On opening the bags at the 1958 Divisional conferences it was found that the treated groundnuts were undamaged, but the untreated ones had been reduced to holed shells containing powder. It was pointed out to the farmers that the treatment had given protection for twelve months whereas seed nuts are normally stored for no more than six months.

Farmers are now accepting the seed nut scheme and realizing its undoubted advantages. As a follow-up of the free lindane issue, permanent stores were built in certain villages in the Protectorate and were opened for the storage of seed in December 1959. There is no question of compelling the farmers to use a store but they are encouraged to bring their

seed to the store at a previously specified date. The seed is then dusted with lindane, and the bags are sealed and labelled. Each store has two different locks and the key to one lock is held by the village head while the other is kept by the local Agricultural Officer.

It can be said that Green's recommendations regarding the insecticidal treatment of seed groundnuts have worked well in practice and there have been few administrative difficulties. With the advent of seed stores it has been proposed, and accepted by the village heads concerned, that the lindane issue to individual farmers will cease, and the village store will become the local lindane store and centre for insecticidal treatment.

Control of the Rust-red Flour Beetle, *Tribolium castaneum* (Hbst.)

All the groundnuts which are destined for export are decorticated before shipment. Of four decorticating mills in the Gambia, two at Denton Bridge near Bathurst, are privately owned and, although old, decorticate for G.O.M.B. on contract. Two mills of more recent construction are owned by G.O.M.B., one at Kaur, some one hundred and twenty miles up river, and the other at Kuntaur, about sixty miles beyond Kaur. The river Gambia is navigable to ocean-going vessels as far as Kuntaur. Shelled nuts are bagged and, except for those placed in a covered store at Bathurst, are stored outdoors while awaiting shipment.

It had been anticipated by Green[3] that the introduction of decortication would increase the risk of infestation by the Rust-red Flour beetle, *Tribolium castaneum* (Hbst.). To reduce this risk, Green recommended that shipment of the shelled nuts should take place as quickly as possible and in strict rotation.

In 1957, when the mills were first inspected by the author, conditions in the G.O.M.B. mills at Kaur and Kuntaur were good. Infestation by *Tribolium* in the mills was negligible as a result of regular cleaning, and a good system of rotational storage and shipment had been introduced. At the Denton Bridge mills, however, conditions were far from satisfactory. Hygiene was poor, and the mills were supporting a heavy infestation of *T. castaneum*. *Oryzaephilus mercator* (Fauv.), *Alphitobius* spp., *Tenebroides mauritanicus* (L.) and *Ephestia cautella* (Wlk.) were also present. Dumps of groundnut shell and residue close to the mills were found to contain heavy infestations of *T. castaneum*. Shelled groundnuts from these mills were not stored and shipped in rotation at Bathurst and, as a result, heavy *Tribolium* infestations developed.

Prior to the start of the 1957/58 trade season, the mills were cleaned thoroughly and the rubbish burned. Shell or other residue was burned as it came from the decorticating machinery. There was, as a result, a marked reduction in the level of visible infestation in the mills but, by April 1958, *Tribolium* infestation was again heavy in shelled groundnuts in Bathurst.

Before the opening of the 1958/59 trade season, the cleaning measures were supplemented by insecticidal spraying. A mixture of 50 per cent. DDT and 25 per cent. lindane water dispersible powders diluted at the

rate of 8 oz. and 3 oz. per gal. respectively was applied at approximately 1 gal. per 1,000 sq. ft. using a motorised knapsack sprayer. Although, after the building had been cleaned, only a light residual infestation was apparent, large numbers of *T. castaneum* adults emerged from crevices during the spraying operation and a heavy kill resulted. The covered store in Bathurst was also cleaned and sprayed, with good results.

During the remainder of the season few insects were seen in the mills and infestations in the shelled groundnuts in Bathurst were markedly lower than previously.

Cleaning and spraying were repeated immediately prior to the 1959/60 trade season. Malathion 25 per cent. dispersible powder was used at a dilution of 1 lb. per gal. and applied at a rate of 1 gal. per 1,000 sq. ft. It was most noticeable that there was not the heavy emergence of *Tribolium* from crevices at the time of spraying, which suggested that the insect population had not built up to its pre-1958 proportions. Furthermore, at the time of writing (March 1960), there was no sign of *Tribolium* in the stacks of shelled groundnuts awaiting shipment from Bathurst. Some of these had already been stacked for six weeks. It seems likely that, although some *Tribolium* infestation is present at the time of decortication[3], cross infestation in the mills plays a large part in the subsequent build-up of infestation during storage.

General Observations

Observations made in the field, and various experiments have tended to support Green's[1] estimate of about five weeks for the life cycle of *C. gonagra*. His predicted periods of marked increases in adult population have also been confirmed. The five-week life cycle appears to be restricted to the dry season however; during the rains when generally lower temperatures and higher humidities occur, small-scale experiments showed that a life cycle of about seven weeks took place.

It seems likely that some infestation of groundnuts by *C. gonagra* occurs before the crop has been removed from the fields. In December 1958, one week after the trade season had opened, groundnuts from which adults had emerged were seen by the author at Denton Bridge mills. Oviposition must have taken place some five weeks previously in mid-November, when the groundnuts were drying in the field. The few damaged groundnuts were from the Kombo district around Bathurst, and it is the practice of the traders early in the season to purchase in the field and transport direct to the mill.

During the 1958/59 trade season, a few hand decorticators of a type used widely in Nigeria were introduced among the co-operative societies in the Kombo district. The resulting shelled groundnuts were superior to those from the mills in that the percentage of broken kernels was much lower. Should this method be adopted generally the export crop would not be stored in shell for a long period and the *Caryedon* problem would become less serious. There would almost certainly, however, be an increased liability to attack by *T. castaneum* resulting from a longer period of storage. During the early part of this new storage period the crop would tend to be in small parcels, widely dispersed throughout the

territory and, therefore, less subject to supervision and inspection than when decorticated centrally. Fumigation followed by protective spraying might then become a necessity unless some means is devised of protecting the shelled groundnuts with contact insecticides.

It must be said that progress in the control of infestation in the export crop has not been as rapid as had been hoped, particularly with regard to *C. gonagra*, partly due to the apathy of many traders, and partly to the difficulty of transporting materials and staff in an under-developed territory. The picture so far as seed nuts are concerned is much more encouraging and considerable progress has been made in this important sphere.

Conclusions

1. Where they have been put into effect, the recommendations made by Green[2, 3] have been entirely successful.
2. Infestation by *C. gonagra* of trade nuts has been markedly reduced but will remain a serious problem so long as the trader has no incentive and lacks enthusiasm.
3. Complete protection of seed nuts is achieved by admixing 0·5 per cent. lindane dust at a rate of not less than 6 oz. per cwt. With the free issue of lindane to farmers who save their own seed, the infestation of seednuts by *C. gonagra* is being brought rapidly under control.
4. There remains the continuous threat of heavy infestation of shelled groundnuts by *T. castaneum*. Where, for any reason there is a long delay between decortication and shipment, serious infestations are inevitable. Investigation into further possible methods of preventing the build-up of *Tribolium* infestations is therefore required.

Acknowledgements

My thanks are due to Mr. A. A. Green at whose suggestion this paper was written, and whose criticisms and advice have been invaluable. I also acknowledge the help and advice of other members of the staff of the Pest Infestation Laboratory given on numerous occasions during the past three years.

The co-operation of the General Manager of the Gambia Oilseeds Marketing Board has been much appreciated.

This paper is published with the permission of the Government of the Gambia.

References

(1) Green, A. A., 'The control of insects infesting groundnuts after harvest in the Gambia. I. A study of the Groundnut borer, *Caryedon gonagra* (F.) under field conditions'. *Trop. Sci.*, 1959, **I**, No. 3, 200.

(2) Green, A. A., 'The control of insects infesting groundnuts after harvest in the Gambia. II. Field trials on the control of the Groundnut borer, *Caryedon gonagra* (F.)'. *Trop. Sci.*, 1960, **II**, Nos. 1 and 2, 44.

(3) Green, A. A., 'The control of insects infesting groundnuts after harvest in the Gambia. III. The effects of decortication on the infestation of groundnuts by *Tribolium castaneum* (Hbst.) and other insects'. *Trop. Sci.*, 1960, **II**, No. 3, 130.

(4) Hall, D. W., 'Storage of produce in the Gambia'. *Trop. Sci.*, 1959, **I**, No. 3, 193.

The Production of Hardboard from Tropical Timbers

VI. Kapur *(Dryobalanops* spp.*)*, Keruing *(Dipterocarpus* spp.*)*, Red Seraya *(Shorea* spp.*)*, and White Seraya *(Parashorea plicata)*

By D. F. Packman
Forest Products Research Laboratory

Summary

Satisfactory hardboard was made on an experimental scale from each of four species grown in North Borneo and from a mixture of two of them. After treatment of the wood chips in a laboratory Asplund Defibrator no further refining of the fibre or additions of water-proofing or bonding agents were found to be necessary. Desirable qualities of strength and water resistance were obtained by a suitable choice of conditions in the press followed by hot air treatment of the boards.

Introduction

Accounts have already been published[1, 2, 3] of investigations made at the Forest Products Research Laboratory concerning the suitability of certain Malayan woods for the manufacture of hardboard. These included red meranti (*Shorea leprosula*) and keruing (*Dipterocarpus crinitus*). The timber used in the present investigation was grown in North Borneo and, although two of the species were closely allied to the Malayan woods mentioned above, special interest was expressed in their suitability, and particularly in the possible use of mixtures of red and white seraya. This paper describes the results of experiments made on a laboratory scale in which the Defibrator process was applied to each of the four species individually and to a mixture of the two kinds of seraya.

Experimental

(1) Kapur

The timber was received already cut into billets of 4 in. × 4 in. cross section, suitable for feeding direct to the experimental chipper.[2] The average moisture content was found to be approximately 18 per cent. on oven-dry weight basis. At this moisture content the bulk density was 48 lb./cu. ft., a value slightly above the average quoted for timber of this species grown in Borneo. By standard *Tappi* methods of analysis, the wood was found to have a moderately high water soluble content. Cold

water extraction removed 5·6 per cent. and hot water 7·6 per cent., by weight. Solubility in alcohol-benzene mixture, however, was comparatively low, accounting for only 2·3 per cent.

Cleanly-cut chips were produced by the laboratory chipper and these were readily defibred in the laboratory Asplund Defibrator[4] to give a very free draining pulp. Twenty batches of chips, each equivalent to 400 g. oven-dry wood, were treated for one minute in the Defibrator at each of three different temperatures. The first series was treated at 125 lb./sq. in. gauge pressure in saturated steam, equivalent to 178°C., the second at 150 lb./sq. in. and 185°C., and the third at 175 lb./sq. in. and 192°C. The resulting fibre from the 20 batches in each series was combined and mixed to give three pulp stocks which were then wet-screened through a ·040 in. slotted screen to remove shives before pressing into boards. Shive content was low, being from 1 to 2 per cent. in each case and negligible drainage time was recorded for each of the pulps, measured on a Williams Freeness Tester using a 5·0 g. sample. Efforts to refine the pulps in a Sprout-Waldron laboratory disc mill met with little success, very small increase in drainage time being obtained in spite of the readiness with which the average fibre length was reduced and the rapid increase in the proportion of extreme 'fines'. The distribution of fibre or fibre-bundle lengths was measured by means of a pulp fractionater fitted with rotating disc standard screens. The results of these determinations together with yield data and drainage times for the three unrefined pulp stocks are shown in Table I, also results for a refined portion of the pulp defibred at 175 lb./sq. in. 'Power index' data included in Table I are not quoted in absolute units of power but represent numerical expressions of the average power consumption during defibration, comparable within the experimental limits of the investigation.

Wet mats containing 80 per cent. moisture, by weight, made in the laboratory sheet former from a 0·5 per cent. aqueous suspension of each of the three unrefined pulp stocks, were hot pressed for a total time of 10 minutes at 1,000 lb./sq. in. to make hardboard samples 10 in. sq. and $\frac{1}{8}$ in. thick. Some were pressed at 185°C. and others at 210°C. Two different closing rates were applied to the press platens at each temperature. At one rate the pressure on the mat was built up from zero to 1,000 lb./sq. in. in 6 seconds, while at the other the time taken was 35 seconds. Some of the boards pressed under each combination of temperature and closing speed were heat treated at 180°C. for 2 hours, in circulating air. All the board samples were then conditioned to constant weight at 65 per cent. relative humidity and 25°C. before testing for bending strength and water absorption under standard conditions.[1] The results of these tests, shown in Table II, represent mean values for groups of not less than four boards each.

As may be seen from the data, somewhat stronger boards were made from each pulp stock by pressing at 210°C. rather than at 185°C. It is also apparent that the faster closing of the press produced boards of higher specific gravity and increased bending strength. Modulus of rupture data, after correction to a nominal specific gravity of 1·000, by application of the conventional square law relationship,[5] showed a small gain in

each case for the boards pressed at the higher speed, indicating that the improvement was at least partly effected by more efficient bonding within the board and was not merely due to the effect of increased specific gravity in the strength-testing procedure. In all cases, heat treatment after pressing effected a very considerable reduction in water absorption as measured by the gains in weight and thickness of the boards after 24 hours immersion in water at 20°C. This effect was accompanied by substantial gains in strength. Under any selected combination of pressing conditions there was little significant variation in specific gravity between boards made from the three different pulp stocks. Those made from pulp defibred at the lowest temperature were intrinsically slightly stronger than the others, although the significance of the apparent difference is doubtful and would not in any case warrant the extra consumption of power in preparing the pulp.

In general, it may be seen that by the selection of a suitable temperature and closing speed in the press, followed by hot air treatment, boards from either of the pulps could be made which met the requirements for strength and water resistance of B.S. 1142 for Super Hardboard, or Federal Specification LLL-H-35 for Class I Standard Hardboard. For Super Hardboard, in $\frac{1}{8}$ in. thickness, the British Specification requires a minimum modulus of rupture of 5,630 lb./sq. in. coupled with a maximum water absorption of 20 per cent. by weight. The American specification for Class I Standard Hardboard in this thickness requires a minimum modulus of rupture of 5,500 lb./sq. in. combined with maximum water absorption of 20 per cent. by weight and 16 per cent. increase in thickness due to swelling.

Although quite free from 'water-burns' or blisters which might possibly have been expected as a result of the rapid build-up of pressure with the faster press closing time, many of the boards made from either of the pulps and under any of the pressing schedules were of poor appearance due to dark-stained patches on the surface. These were caused apparently by the charring of water-soluble matter unevenly deposited on the surface during evaporation of water in the press. Some boards were made up from portions of each of the pulp stocks which had been specially washed with large quantities of water in the wet screen as an additional treatment to the normal screening. These were much improved in appearance and their strength properties were not impaired.

(2) Keruing

Received in the form of air-dry billets of 4 in. × 4 in. cross section this timber was found to have an average bulk density of 39 lb./cu. ft. Recorded data for the species show that the range of density may be from 39 to 59 lb./cu. ft. in the seasoned condition, with an average figure of 45. This sample therefore could be regarded as lighter than average. Water-soluble content was low, 1·2 per cent. being removed by cold water and 4·5 per cent. by hot. Alcohol-benzene extraction removed 4·4 per cent. The grain was much interlocked throughout all the wood supplied, with the result that the natural planes of cleavage were not parallel and many of the chips produced had thickened portions in the

centre. As with kapur, 20 batches of chips, each equivalent to 400 g. dry wood, were treated for one minute in the Defibrator at each of three different temperatures. Owing to the uneven thickness of the chips, mentioned above, a number of the thicker, cross-grained portions remained whole after the defibration treatment. Lengthening the time of treatment for a single batch had no beneficial effect and it was necessary to separate the solid pieces by passing the defibred material through a $\frac{1}{2}$ in. screen, in the semi-dry condition, immediately after treatment. Rejects were returned to the Defibrator with each succeeding batch of chips so that the overall yield of fibre for 20 batches was not diminished.

As with kapur, pulps having negligible drainage time were produced at each of the selected defibration temperatures. The power consumption was of approximately the same order, decreasing in inverse proportion to the treating temperature. As shown in Table III, the distribution of fibre, or fibre bundle, lengths was similar to that in the pulps from kapur with an overall slight increase in the amount of coarse material and rather less 'fines'. Wet screening separated a quantity of shive which was reduced by a single pass through the Sprout-Waldron laboratory disc mill, fitted with plates No. 12527A set at a nominal clearance of ·005 in. The defibred shive material was returned to the combined pulp stock for each series of 20 batches.

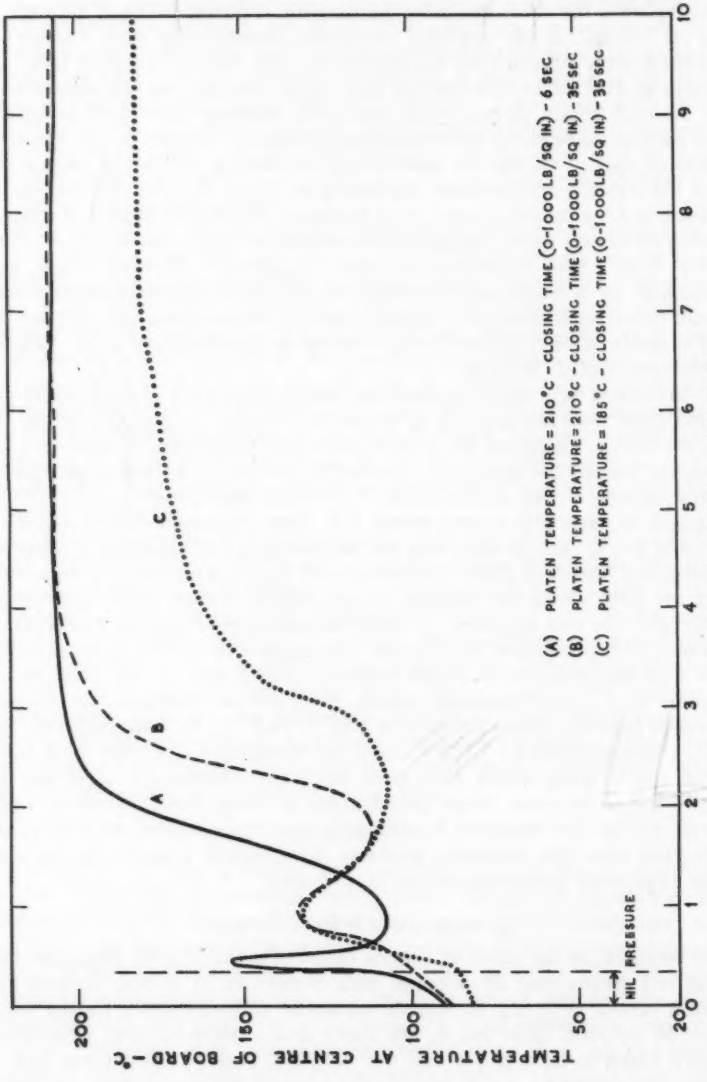
Wet mats were made in the sheet former from each of the pulp stocks and these were hot-pressed, as before, for 10 minutes at 1,000 lb./sq. in. Two rates of closure of the press platens were employed, as described for kapur, but all the mats were pressed at 210°C. As before, some boards were treated in hot air at 180°C. for 2 hours after pressing. Six or more boards in each group were tested and, from the mean results shown in Table IV, it may be seen that the higher rate of application of pressure produced boards of slightly higher specific gravity and strength from each of the pulp stocks. As with the kapur boards, a part of the increase in strength was still apparent in values for modulus of rupture corrected to a nominal specific gravity of 1·000. An added effect of the faster pressing was an improvement in water resistance which was, in any case, much better than that of the kapur boards. After hot air treatment, fast pressed boards from the pulps defibred at 185°C. and 192°C. complied with the U.S. Specification for Class I Standard Hardboard but only those from the 192°C. pulp could be classed as Super Hardboard according to British Specification. Some boards from all three pulps, however, were well within the Standard Hardboard category according to B.S. 1142. For this class the minimum modulus of rupture is 4,900 lb./sq. in. and the maximum water absorption 30 per cent.

(3) Red and White Seraya

As received, in the form of air-dry billets of 4 in. × 4 in. cross section, the red seraya had an average bulk density of 31 lb./cu. ft. and the white seraya 37 lb./cu. ft. Soluble extractive materials in the timber were low in amount. Cold water, hot water and alcohol-benzene solubilities were found to be 0·4, 1·0 and 2·0 per cent. respectively for red seraya and 0·7, 1·5 and 3·4 per cent. for the white. Uniform, cleanly cut chips

of both species produced by the laboratory chipper readily responded to treatment in the laboratory Defibrator. Twenty batches of chips, each equivalent to 400 g. dry wood, were treated from each of the two species separately. A further 20 batches, consisting of equal weights of the two species mixed together, were also treated. In each case the chips were

Temperature, During Pressing, in Boards of Mixed Red and White Seraya



treated for one minute in the Defibrator in saturated steam at 150 lb./sq. in. gauge pressure. The resulting fibre from each series of 20 batches was combined and wet screened. Shives were separated and refined by passing through the disc refiner, as described earlier for keruing, then returned to the main pulp stocks. Comparatively coarse pulps with low drainage times were produced in high yield from each of the species separately as well as from the mixture. Yield, fractionation data and power consumption index for each of these pulps are shown in Table V.

Boards from each pulp were pressed at 210°C., using two closing rates in the press as described earlier. Heat treatment, after pressing, was applied to a number of the boards pressed at each rate from each of the three pulps. Mean test results shown in Table VI were obtained from groups of not less than six boards each. Thermocouples were inserted in some of the boards made from the red and white seraya mixture and the temperature at the centre of the mat was recorded during the pressing period. The figure shows curves for the temperature-time relationship in boards pressed at 210°C. platen temperature, with press closing times of 6 and 35 seconds. Also shown is a curve obtained from a board, not included in Table V, from the same pulp pressed at 185°C. with the slower press closing rate.

As may be seen from Table VI, boards of higher strength were made from red seraya than from any other species tested under the same conditions. Even at the slower pressing rate, with heat treatment, they easily satisfied requirements of the British Specification for Super Hardboard and the Federal Specification for Class I Standard Hardboard. Pressing at the faster rate resulted in further gains in strength. Boards made from white seraya were somewhat lower in quality but the application of heat treatment to those pressed at the faster rate brought them into the categories of Super and Class I Standard Hardboards.

As might be expected, the treatment of the mixture of equal quantities of the two kinds of seraya produced boards with qualities intermediate between those made from the two species separately. After heat treatment, boards made from the mixture proved to be completely satisfactory with regard to either of the specifications.

Discussion

The results of the various tests carried out on kapur and keruing (Tables I, II, III and IV) showed that variation of steam pressure in the Defibrator within the range 125 to 175 lb./sq. in. had little effect on either the yield of pulp or overall qualities of the boards. As might be expected, however, the power consumed during defibration varied inversely with the steam pressure. In the case of kapur, it was shown (Table II) that higher strength properties resulted from pressing at a platen temperature of 210°C. rather than 185°C. The higher temperature was adopted as standard for subsequent tests on the other three species. With the experimental press used for these tests it was found that 6 seconds was the shortest reproducible time in which a pressure of 1,000 lb./sq. in. could be applied to the wet mat. In all cases, boards pressed with this platen-closing time showed higher strength than others pressed in such a way

that maximum pressure was reached in 35 seconds. Probably due to the very free nature of all the pulps used, none of the boards were blemished with 'water burns' as a result of rapid pressing and there was no necessity to breathe the mats during the pressing period. As the figure shows the temperature in the wet mats reached a peak value of 130°C. to 150°C. at about the time when maximum pressure was attained. This was followed in each case by a considerable drop in temperature, although pressure was maintained, during the period of rapid evaporation of water from the mat, after which there was a steady rise to the platen temperature. The initial peak value was approximately the same for boards pressed at platen temperatures of either 185°C. or 210°C. at the slower press-closing rate. With the faster pressing, however, the initial peak was rather higher and the subsequent evaporation of water was effected much more quickly. The increase in density and strength in the boards, obtained by rapid pressing, may possibly have been due to enhanced plastic flow of the lignin in the fibre as a result of the higher degree of superheating of water in the mat before evaporation.

The actual closing time of 6 seconds was not shown to be a critical value but, as mentioned earlier, it was the shortest time attainable under the conditions of the experiment. Although it is unlikely that closing could be effected so rapidly in a large-scale press the results are of value in indicating the gains in quality which may be expected by pressing as fast as the freeness of the pulp will allow. Improvements effected in this way can be made to offset poor quality in the original fibre or, as in these experiments, may render unnecessary the extravagant use of power for refining coarse pulp.

Conclusions

Satisfactory boards were made from each of the species and from a mixture of red and white seraya by the Defibrator process. No further refining of the pulp after defibration or any additions of wax or similar water-proofing agents were found to be necessary, the desired qualities of strength and water resistance being obtained by a suitable choice of pressing conditions followed by hot air treatment.

Of the four species tested, red seraya produced boards of the highest quality and in the highest yield. The mixture of red and white seraya presented no special difficulty.

Boards from kapur tended to be poor in appearance due to the presence in the timber of highly-coloured water-soluble extractives. Although it was found that these could be removed sufficiently by thorough washing of the pulp this step might prove to be a serious disadvantage to large-scale production of board because of the unavoidably high overall consumption of water.

Keruing presented certain mechanical difficulties due to the preponderance of interlocked grain in the sample tested. Thick cross-grained portions of chips which failed to respond to treatment in the small laboratory Defibrator would, no doubt, be completely defibred in a full-scale Defibrator of the disc type where throughput is continuous. Nevertheless, on the commercial scale, this material might be responsible for rather

high consumption of power both in the chipping and in the defibration stages.

Acknowledgement

The research upon which this communication is based was carried out as part of the programme of the Forest Products Research Laboratory on behalf of the Colonial Products Council. It is published by permission of the Department of Scientific and Industrial Research and the Colonial Products Council.

References

(1) Farmer, R. H. and Packman, D. F., 'The Production of Hardboard from Tropical Timbers. I'. *Colon. Pl. Anim. Prod.*, 1954, **IV,** 293-309.
(2) Farmer, R. H. and Packman, D. F., 'The Production of Hardboard from Tropical Timbers. II'. *Colon. Pl. Anim. Prod.*, 1955, **V,** 39-50.
(3) Packman, D. F., 'The Production of Hardboard from Tropical Hardwoods'. VIIth British Commonwealth Forestry Conference, 1957.
(4) Packman, D. F., 'The Production of Hardboard from Tropical Timbers. IV'. *Trop. Sci.*, 1959, **I,** 5-12.
(5) Turner, H. D., Hohf, J. P. and Schwartz, S. L., 'Effect of Some Manufacturing Variables on the Properties of Fibreboard Prepared from Milled Douglas Fir'. *Proc. For. Prod. Res. Soc.*, 1948, **2,** 110-112.

TABLE I

Pulp from Kapur by the Defibrator Process

Pulp Series	Defibrating Conditions		Pulp Yield per cent.	Power Consumption index	Fibre Classification						Williams Freeness sec. (5·0 g. sample)
	Steam Pressure lb./sq. in.	Temp. °C.			Above 10 mesh	10/14	14/25	25/52	52/100	Below 100 mesh	
A	125	178	88	25	6	7	17	32	20	18	6
B	150	185	85	19	12	8	18	27	16	19	6
C	175	192	86	15	13	8	20	25	14	20	6
Portion of C, refined in disc mill					3·5	5	13·5	22	23	33	10

TABLE II: *Boards from Kapur*

Pulp Series	Pressing Conditions		Heat Treatment at 180°C.	Sp. Gr.	Modulus of Rupture (lb./sq. in.)	Modulus of Rupture Corrected to Sp. Gr. = 1·000	Water Absorption	
	Platen Temp. °C.	Closing time to Max. Pressure (sec.)					Gain in Wt. per cent.	Swelling per cent.
A	185	35	nil	·953	4615	5080	71	50
			2 h	·931	5950	6860	15	18
		6	nil	·962	5090	5495	92	83
			2 h	·989	6325	6475	14	13
	210	35	nil	·949	4950	5495	78	57
			2 h	·954	6145	6760	15	14
		6	nil	·986	5800	5965	49	40
			2 h	·969	6550	6970	14	15
B	185	35	nil	·907	4000	4870	128	79
			2 h	·904	4975	6085	16	16
		6	nil	·956	4515	4940	129	89
			2 h	·947	5605	6250	16	16
	210	35	nil	·923	4560	5360	61	48
			2 h	·917	5530	6580	16	16
		6	nil	·961	5185	5615	62	46
			2 h	·941	6065	6855	14	16
C	185	35	nil	·941	3800	4293	136	85
			2 h	·925	4838	5653	15	14
		6	nil	·960	4480	4860	94	80
			2 h	·948	5405	6030	14	15
	210	35	nil	·958	4500	4930	82	57
			2 h	·967	5275	5640	20	20
		6	nil	·986	5185	5335	97	71
			2 h	·993	6040	6125	16	16

TABLE III

Pulp from Keruing by the Defibrator Process

Pulp Series	Defibrating Conditions		Pulp Yield per cent.	Power Consumption index	Fibre Classification per cent.						Williams Freeness sec. (5·0 g. sample)
	Steam Pressure lb./sq. in.	Temp. °C.			Above 10 mesh	10/14	14/25	25/50	50/100	Below 100 mesh	
A	125	178	81	22	12	9	17	28	21	13	6
B	150	185	81	16	17	10	19	26	21	7	6
C	175	192	82	12	18	9	18	24	20	11	6

TABLE IV

Boards from Keruing

Pulp Series	Pressing Conditions		Heat Treatment at 180°C.	Sp. Gr.	Modulus of Rupture (lb./sq. in.)	Modulus of Rupture Corrected to Sp. Gr.= 1·000	Water Absorption	
	Platen Temp. °C.	Closing time to Max. Pressure (sec.)					Gain in Wt. per cent.	Swelling per cent.
A	210	35	nil	·961	4340	4700	24	22
			2 h	·972	4745	5020	15	13
		6	nil	·970	4625	4920	20	20
			2 h	·981	5370	5588	13	13
B	210	35	nil	1·011	4163	4075	17	14
			2 h	1·046	5038	4608	13	11
		6	nil	1·061	5050	4488	12	12
			2 h	1·055	5620	5068	12	10
C	210	35	nil	1·037	4715	4370	17	13
			2 h	1·019	4975	4793	12	10
		6	nil	1·047	5015	4578	14	12
			2 h	1·058	5645	5058	10	9

TABLE V

Pulp from Red and White Seraya by the Defibrator Process

Wood Sample	Pulp Yield per cent.	Power Consumption index	Fibre Classification per cent.						Williams Freeness sec. (5·0 g.)
			Over 10 mesh	10/14	14/25	25/52	52/100	Below 100 mesh	
Red Seraya	89	21	18	7	14	23	19	19	6
White Seraya	84	18	16	8	18	26	16	16	6
Red and White Seraya Mixture	89	22	18	7	16	25	18	16	6

TABLE VI

Boards from Red and White Seraya

Wood Sample	Pressing Conditions		Heat Treatment at 180°C.	Sp. Gr.	Modulus of Rupture lb./sq. in.	Modulus of Rupture Corrected to Sp. Gr.= 1·000	Water Absorption	
	Platen Temp. °C.	Closing time (sec.)					Gain in Wt. per cent.	Swelling per cent.
Red Seraya	210	35	nil	1·066	6490	5710	38	27
			2 h	1·058	7695	6870	12	12
		6	nil	1·084	6753	5745	35	25
			2 h	1·076	8008	6915	11	12
White Seraya	210	35	nil	1·043	4200	3860	45	30
			2 h	1·019	5020	4840	13	15
		6	nil	1·076	5015	4330	41	28
			2 h	1·040	5740	5308	12	14
Red and White Seraya mixture	210	35	nil	1·042	5090	4680	42	27
			2 h	1·034	6115	5453	12	13
		6	nil	1·067	5608	4925	40	28
			2 h	1·059	6388	5980	11	12

A Review of the Market and World Trade in Bananas

By Mrs. D. E. Kay and E. H. G. Smith

Bananas are consumed in many countries of the world and are generally available throughout the year, with relatively little variation in price. The cultivation of bananas is confined to the tropics or subtropics, where they are widely grown, although the conditions necessary for producing fruit on a large scale commercially are found only in a relatively few countries. At present bananas are the fourth largest fruit crop of the world being only exceeded by grapes, citrus fruits and apples. However, unlike bananas, which have no important outlets except for consumption as fresh fruit, considerable quantities of these other fruits are utilized by processing industries.

World production of bananas is estimated to have amounted to about 21 million tons in 1957, although exact details are difficult to obtain, since many countries include plantains in their estimates of the crop. In addition, the major portion of the world output is consumed locally as a staple food crop, particularly in Africa, parts of Asia and Oceania. The cultivation of bananas for international trade, is largely centred in South and Central America (including the West Indies), although West Africa, Oceania, and the Canary Islands also produce considerable quantities of fruit for export. It has been estimated that only between 15 and 25 per cent. of the world production of bananas enters international trade; yet bananas probably account for about 40 per cent. of the world trade in fresh fruit. This is remarkable, in view of the highly perishable nature of the banana and the fact that it is a bulky fruit which is usually shipped attached to a stem. The clusters of fruits, or fingers, protrude from their stem in a way that facilitates crushing and bruising, unless the bunches are handled very carefully. In this connection a recent development has been the wrapping of the bunches in polythene to protect the fruits during shipment.

The two chief types of bananas entering world trade are the Jamaican or Gros Michel (*Musa sapientum* L.) and the different varieties of the Cavendish group (*Musa cavendishii* L.) which includes the Canary banana and the Lacatan. The Gros Michel is the more hardy fruit to transport and is the most important variety entering the world market, since it is easier to handle and less susceptible to chilling injuries during shipment than the Cavendish varieties. However, the plant itself is more specific in its requirements and is very susceptible to Panama disease. This soil-borne fungoid disease is very destructive and is a limiting factor to banana cultivation in many areas, since it attacks the rhizome and root system of the plant, often resulting in its complete destruction. The only method of control which appears likely to be effective is a system of 'flood fallow-

ing' which is being developed by the United Fruit Company in Central and South America and which is only suited to large scale plantations. In view of the serious nature of Panama disease and the poor commercial qualities of the true Cavendish or Canary banana a number of other varieties of bananas have been developed by selection. These all belong to the Cavendish group, although they have better marketing and shipping qualities than Canary bananas and yet have retained, so far, resistance to Panama disease. The most important of these varieties is the Lacatan, and this fruit is now replacing the Gros Michel in certain areas which have been devastated by this disease.

Bananas are always harvested in a green state before full maturity. The exact stage of maturity at which the fruit is cut depends largely upon the length of time the bananas are likely to be in transit. A stem or bunch of bananas as harvested usually contains 6 to 14 hands or clusters of fruits. In Jamaica bananas for export are purchased on the basis of a stem of 9 or more hands which constitutes a 'count' bunch of fruit. Stems of 8 hands are termed '$\frac{3}{4}$ count' bunches, 7 hands '$\frac{1}{2}$ count', and 6 hands '$\frac{1}{4}$ count'. Stems with fewer than 6 hands are of no value for export and the minimum buying weight for a '$\frac{1}{4}$ count' bunch is 20 lb.

After harvesting, the bananas are quickly transported to the ports and loaded for export. On board ship the fruit is usually rapidly cooled to 53°F. to 54°F. and then kept at a temperature of about 52°F. to 56°F. for the duration of the voyage, depending upon the variety and the degree of maturity of the fruit. On arrival at their country of destination the bananas are ripened artificially, normally in specially constructed ripening rooms where the temperature and humidity can be carefully controlled. The temperature at which the fruit is ripened varies according to the variety, degree of maturity and outside temperature. In the United Kingdom the fruit is usually ripened at 60°F. to 65°F. in the summer and, in winter at 70°F. to 75°F. These temperatures are maintained for from 12 to 24 hours and are then reduced to 60°F. to 62°F. Relative humidity is also an important factor in ripening since a high humidity is necessary to avoid excessive shrinkage. The relative humidity of the ripening chambers is generally maintained at 85 to 95 per cent. during the initial stages of ripening and is then reduced to 75 to 85 per cent., or even less, to avoid mould growth on the fruit. Shrinkage, that is, loss of weight and wastage, is an important factor in the marketing of bananas and may vary from between 10 and 12 per cent. to as much as 21 per cent. or even more, depending upon the number of fruit on each bunch which have to be rejected as unsaleable. However, there is always a 7 to 8 per cent. loss represented by the weight of the stem to which the hands are attached. With the Gros Michel banana, the shrinkage factor tends to be less than with other varieties, but there are wide variations even with this fruit, according to season, and degree of maturity when harvested. Ecuadorian Gros Michel bananas, for example, consistently show a high shrinkage factor because they are generally carelessly handled at the ports.

The Gros Michel banana is favoured by buyers on account of its low shrinkage factor and the fact that it has several advantages over other

varieties in size and shipping qualities. It is a large fruit and the fingers hug the stem rather than protrude, thus the fruits suffer less from crushing and abrasion during shipment. Their thick stems also reduce the incidence of breakage of the bunches. In addition, Gros Michel bananas ripen uniformly under normal conditions to produce a pale yellow fruit, free from external blemishes. Unfortunately, both Lacatan and Canary bananas are much more susceptible to handling injuries and are more difficult to ripen uniformly. With Canary bananas, for example, there is a tendency for the inside of the fruit to ripen before the outside and both this variety and the Lacatan are much more liable to develop external blemish marks on the skin which detract considerably from their appearance. Another advantage of the Gros Michel banana, which is also shared by the Lacatan, is its comparatively long retail shelf life. Under normal conditions in the United Kingdom these two varieties will remain in good condition for from 10 to 14 days compared with a shelf life of three to four days for Canary bananas.

World trade in bananas began about 80 years ago; production of the fruit for export was limited initially to Central America, which supplied the United States and Canadian markets and the Canary Islands whose exports were mainly consigned to the United Kingdom. World exports increased very rapidly from a few thousand tons in 1880 to more than 1 million tons in 1914 and, by the outbreak of the last war, exports averaged about 2·5 million tons a year. The war completely dislocated the banana trade owing to the restriction of shipping space and it was only in the early 1950's that the trade recovered and again expanded. South and Central America are the dominant banana exporting areas of the world with the West Coast of Africa and the Canary Islands now the only other exporting regions of significant importance. In 1958, world exports of bananas totalled some 3·5 million tons, an increase of 40 per cent. over the pre-war 1938 figure. Details of world exports by countries of origin for the years 1938 and 1954 to 1958 are given in Table I. Examination of this table shows a considerable change in the status of some of the exporting countries. Many of the Central American countries have either only managed to maintain their output of exportable fruit at its pre-war level or, as in the case of Jamaica, Mexico, Guatemala, Nicaragua and Cuba have exported considerably reduced quantities. For example, in 1938, Jamaica was the world's leading exporter of bananas but the industry was at that time suffering from the effects of Panama disease and this, combined with the cessation of exports during the war years, very much reduced the output of fruit. After the war, with the return of more normal trading conditions, the rebuilding of the industry was begun and efforts were made to replace the Gros Michel variety by the Lacatan. This replacement has proceeded rapidly and combined with improved cultivation techniques, particularly the control of leaf spot, or Sigatoka disease by spraying, has enabled exports to rise sharply, although they are still very much below the pre-war level. The effect of Panama and Sigatoka diseases on banana production in those countries where producers have not had the resources to organize effective control measures is shown by the experience of such countries as Mexico,

Nicaragua and Cuba where output has dropped sharply and exports are very much reduced when compared with pre-war years. The marked decrease in exports from Formosa in post-war years is due primarily to the loss of the Japanese market.

Compared with the decline of exports from the older Central American banana producing countries there has been a steady increase in production in South America, notably in Ecuador, in parts of Africa and on a smaller scale in the Windward Islands. The rise of Ecuador as a banana exporting country has been dramatic. Exports from that country were insignificant compared with those of other Latin American countries until the end of the war; since then they have increased more rapidly than those of any other country. By 1952, Ecuador had become the world's leading banana exporter and has continued to maintain that position, contributing about 20 per cent. of the world's total exports in 1958. The Gros Michel is the chief banana variety exported from Ecuador and it has not yet suffered from Panama disease to the same extent as in other Latin-American countries. However, the control of Sigatoka disease in Ecuador has become a serious problem, as it is very widespread and virulent and reports suggest that it is likely to be a limiting factor to any further increase in banana production in that country.

It is interesting to note that, during the last three decades, there has been a steady increase in shipments of bananas from the hitherto dependent territories of European countries to Western Europe. France originally imported large quantities of bananas from the Canary Islands and Latin America but in recent years has obtained supplies almost exclusively from the French territories in Africa and the Caribbean. In Italy the banana trade is a state monopoly and since 1935 supplies have been obtained almost entirely from Somalia (previously Italian Somaliland).

World imports of bananas have risen steadily in recent years; Table II gives details of banana imports and shows that the principal outlets for the fruit are the United States and Western Europe. In 1958, for example, the United States took some 41 per cent. of the total world imports followed by the Federal Republic of Germany 11·4 per cent., France 9·2 per cent., the United Kingdom 8·5 per cent. and the Argentine Republic 6·8 per cent. It is noteworthy that in recent years the most important trend in world trade has been the marked increase in the consumption of bananas in many European countries and the decline in the United States. Although total imports of fresh bananas into the United States have risen from 1·2 million tons in 1938 to some 1·5 million tons in 1958, expansion of that market on a *per capita* basis has practically ceased since the early 1930's as consumption per head has fallen from an annual average of some 22½ lb. for the years 1934 to 1938 to about 19 lb. for the years 1955 to 1957. This drop in banana consumption in the United States has been attributed largely to the decline in the demand for fresh fruit. There has been a distinct shift in that country from the consumption of fresh fruit to processed fruit products. However, the decline in consumption of bananas has been moderate when compared with most other fruits, but it would appear to be continuing, although rather more slowly. In recent years the United States has obtained about 75 per cent.

of its banana imports from Ecuador, the Honduras Republic and Panama, with lesser quantities from Costa Rica, Guatemala and the Dominican Republic. Additional details of American imports of bananas and their source are given in Table III.

Before the war the United Kingdom provided the second largest market for fresh bananas and was by far the most important importing country in Europe. The bulk of the pre-war imports were received from Jamaica, with Brazil, Colombia, the Canary Islands and Nigeria also sending moderate quantities. Imports during the war years virtually ceased, and in the years immediately afterwards were on a very much reduced scale owing to the considerable drop in the quantities received from Jamaica and import restrictions on fruit from non-Commonwealth countries. In fact it was not until 1955 that shipments to this country reached the 1938 level of 305,000 tons. For the period 1955 to 1958 imports remained comparatively stable, but in 1959 rose and reached 337,000 tons. It is significant that banana consumption per head in the United Kingdom has not increased above its pre-war level of 13·6 lb. per annum, but in recent years has averaged about 13·4 lb. Jamaica has continued to be the principal source of the United Kingdom imports of bananas, although that country's share of the total trade has fallen from 76 per cent. in 1938 to just under 40 per cent. in 1959. Imports from other Commonwealth countries have increased greatly compared with pre-war years, shipments from Nigeria in 1959 amounted to about 57,800 tons, while imports from the Windward Islands reached a record level of 88,700 tons in that year. Moderate quantities of fruit have also been received from Ghana and Trinidad and in 1959 amounted to 1,400 tons and 5,000 tons, respectively. The growth of imports from the Windward Islands is noteworthy. The industry has developed under the encouragement of long term contracts and, in addition, harvesting, shipping, ripening and grading of the fruit is well organized so that, on the whole, the quality is superior to many of the consignments of bananas at present being imported into the United Kingdom from other producing countries.

As may be seen from Table IV, which gives details of United Kingdom imports of bananas, shipments from foreign countries, particularly those from Brazil, have fallen in recent years. An interesting feature is the entry of Spanish West Africa as a supplier to this market; imports from there have risen from some 3,200 tons in 1955 to 8,900 tons in 1959, and in that year they exceeded those received from Brazil. In addition, in 1959, small shipments of bananas from the Dominican Republic were consigned to the United Kingdom, under a quota of 4,000 tons, allocated for imports from the dollar area for the period May to August 1959. These together with small quantities of fruit from other Latin-American exporting countries, which were sent via Continental ports, were the first bananas received from the dollar area since before the war. One reason for the decline in imports received on the United market from foreign countries is the duty payable on bananas from non-Commonwealth countries. In April 1956 the duty was increased from 2*s.* 6*d.* per cwt. to 7*s.* 6*d.* per cwt. In addition, the decline in imports from Brazil and, to a lesser extent from the Canary Islands, is partly due to the fact that both

these countries export true Cavendish bananas, which, as indicated previously, cannot compete with the Lacatan from Jamaica and the Windward Islands, and with supplies from Nigeria, which consist largely of Gros Michel fruit. There is a marked preference among United Kingdom buyers for Gros Michel or Lacatan bananas, which generally command a 20 per cent. higher price on the London market than Canary fruit. At present the United Kingdom market for bananas is extremely competitive and there seems unlikely to be any increased demand in the near future. Supplies are available throughout the year although consumption is usually at its heaviest during the summer months.

The growth of banana consumption in many European countries in post-war years has been phenomenal. Details of imports into the Federal Republic of Germany, France, Belgium and the Netherlands are given in Table V. Imports into the Federal Republic of Germany have risen from 107,000 tons in 1952 to 423,400 tons in 1959, and that country is now the second most important banana market in the world. Supplies are obtained from various countries, although in recent years increasing quantities have been provided by Colombia. Other countries which have exported bananas to the German market include the Honduras Republic, the Dominican Republic and Guatemala, and in some years moderate quantities of fruit have also been obtained from the Canary Islands. Imports of bananas into France have also shown a sharp increase in recent years and, in 1959, amounted to some 336,000 tons. Supplies are obtained almost exclusively from French overseas territories, chiefly Martinique and Guadeloupe.

Other European countries where there has been a striking increase in the consumption of bananas are Switzerland, the Netherlands, Denmark, Austria and Norway. There are obvious reasons for the rise in banana consumption in these countries. Firstly, there is at present a marked consumer preference for fresh fruit compared to processed products in European countries and, secondly, rising incomes and standards of living have favoured an increase in fruit consumption. The demand for bananas has undoubtedly been stimulated by the fact that plentiful supplies have been available in certain countries at comparatively cheap prices. However, with the exception of Norway, consumption of bananas per head in many European countries is still very much below the level in the United States. For example, in 1957, consumption was just over 14 lb. per head in the Federal Republic of Germany, about 12½ lb. per head in Switzerland and only 4½ lb. in Austria, compared with 19 lb. per head in the United States and Canada, and 18 lb. per head in Norway.

It is necessary to examine the probable effect of the European common market on the banana trade. Imports into the six common market countries (Belgium, Luxembourg, France, the Federal Republic of Germany, Italy and the Netherlands) amounted to some 934,000 tons in 1958 and represented about 26 per cent. of the total world trade. As already pointed out, France obtains virtually all her supplies from Martinique, Guadeloupe, French West Africa, Guinea and the French Cameroons, while Italy is supplied mainly by Somalia. The Benelux

countries have hitherto obtained small quantities of fruit from the Congo and the rest from Latin-American countries. The Federal Republic of Germany and the Netherlands also obtain the bulk of their supplies from Latin-American countries. Thus, over half the total requirements of the common market trade area are obtainable from Latin America.

Under the common market treaty there is a tariff of 20 per cent. *ad valorem* on imports of bananas from countries other than the associated territories of member nations. However, since the new tariff would have a serious effect upon the Federal Republic of Germany, which formerly obtained its bananas free of duty and could not obtain all its requirements within the area, there is a special duty-free quota based on the level of German imports in 1956. It is anticipated that the common market treaty may provide an incentive for the Federal Republic of Germany, and possibly the Benelux countries, to obtain a greater proportion of their supplies from the associated territories of member countries, and it seems likely that these markets may become less dependent upon Latin America for their banana requirements. However, up to the present, most of the banana production of the associated territories has been sold to the metropolitan countries at prices above world market levels. For example, in 1958, net import values per ton for France and Italy were £68 and £84 respectively, compared with £49 for the Federal Republic of Germany. Thus, any general switch of the banana trade will be largely determined by the extent to which production in the associated territories can be expanded at prices competitive with outside suppliers.

Apart from Europe and the United States, the more important banana importing countries are the Argentine, Uruguay and Chile in South America, Canada in North America, Algeria, Morocco, Tunisia, Southern Rhodesia, and the Union of South Africa in the African continent, Japan and Hong Kong in Asia and New Zealand in Oceania. Imports into Latin America, as a whole, have remained comparatively stable in recent years at around 200,000 tons per annum, although shipments to individual countries are liable to fluctuate considerably according to current economic and political policy. Consumption in Canada has increased rapidly in post-war years and imports in 1958 amounted to 144,000 tons or almost double those of 1938. As would be expected this expanding Canadian market has been supplied by Central and South American producers. Imports into Japan have been very much reduced in recent years compared with the pre-war period when supplies were obtained from Formosa, which at that time was a Japanese dependency. Compared to pre-war years consumption of bananas in African importing countries has increased considerably, although shipments to these markets are still at a low level. New Zealand is the only important market in Oceania and imports into that country are now approximately 32,000 tons, or double the annual average for the years immediately before the war.

It is difficult to forecast how the future world trade in bananas will develop. Population growth in the two major importing areas would seemingly, in theory, provide a potential increase in demand of something approaching 2 per cent. a year. However, no such growth trend is likely to be realized because in the large United States market the

consumption of fresh fruits has declined. In Europe the rise in the standard of living promises to stimulate a continuing upward trend in banana imports for some time, since consumption per head in many countries is still considerably below that of the United States. In fact some authorities consider that within ten or twenty years Europe could provide a greater outlet for the world banana production than the United States. In addition, the comparatively small market in other non-producing countries may also expand. However, it would seem likely that there will only be a modest growth in the overall weight of bananas that will enter world trade in the foreseeable future, since bananas are meeting with increasing competition from other fruits, particularly citrus and apples, production of which is expanding rapidly.

There is one possible development that could radically change the trade pattern and demand for bananas. At present, all but a negligible fraction of the bananas shipped in international trade is sold to consumers as fresh fruit. However, if experience of the North American market can be taken as being representative of the general world trend, there will be a tendency towards greatly increased sales of processed fruits, i.e. canned and frozen fruits, pulps and juices at the expense of fresh fruits. There are many technical problems connected with the processing of bananas, but if these could be solved and a palatable product produced, at an economic price, which could find wide use by the food processing industry, world consumption of bananas could be increased enormously.

Bibliography

Loesecke, H. W. 'Bananas', Interscience Publishers Inc., New York, 1949.

Cadillat, R. M. 'Le Commerce Mondial de la Banane en 1956', *Fruits*, 1958, **13**, No. 3, 113-28.

Cadillat, R M. 'Le Commerce Mondial de la Banane en 1957', *Fruits*, 1959, **14**, No. 1, 29-46.

May, S. and Plaza, G. 'The United Fruit Company in Latin America', Seventh Case Study in a National Planning Association Series on United States Business Performance Abroad, 1958.

'The International Banana Market: its Evolution and Prospects', *Econ. Bull. for Latin America*, 1955, **3**, No. 2, 13-24.

'Fruit'. Commonwealth Economic Committee, London, 1959.

Wolf, J. 'Development and Structure of the World Banana Market', *F.A.O. Mon. Bull. Agric. Econ. and Statist.*, 1959, **8**, No. 2, 9-18.

Simmonds, W., 'Bananas', Longmans, Green and Co., London, 1959.

TABLE I

World Exports of Bananas by Country
*(in order of importance in 1958)**
Quantity thousand tons

	1938	1954	1955	1956	1957	1958
Ecuador	54	485	600	583	658	731
Honduras Republic	278	275	216	387	360	390
Costa Rica	138	350	324	229	305	297
Brazil	222	235	208	185	215	267
Panama	150	218	271	244	285	263
Canary Is.	103	189	253	264	253	233
Colombia	193	212	241	252	224	220
Jamaica	320	155	145	150	146	122
Guatemala	192	150	125	140	127	114
Guadeloupe	49	76	65	56	78	93
Martinique	37	50	48	70	95	92
Nigeria (British Cameroons)	55	81	67	69	80	86
Dominican Republic	7	43	42	40	51	84
French Cameroons	26	73	75	65	84	72
Guinea	52	82	96	90	72	56
Somalia	20	43	48	36	26	49
Ivory Coast	12	21	47	25	34	45
Formosa	131	29	26	19	25	41
Western Samoa	7	11	18	12	13	35
Mexico	287	55	36	21	45	32
Congo	3	17	30	39	36	28
China	†	†	11	20	16	20
Madeira (a)	—	16	16	20	20	20
Mozambique/Portuguese East Africa	8	19	8	12	20	20
Dominica	1	16	16	21	17	20
St. Vincent	1	—	1	5	16	19
Lebanon	—	6	10	12	11	15
St. Lucia	2	4	6	10	12	14
Grenada	2	1	1	1	8	12
Spanish Guinea	—	2	5	10	13	10
Tonga	1	4	5	7	6	6
Fiji	6	11	12	7	10	5
Ethiopa/Eritrea	—	—	1	1	3	4
Trinidad	1	2	1	3	4	4
Nicaragua	38	12	9	10	2	2
Ghana	1	—	1	1	1	2
British Honduras	16	—	—	1	1	1
Cuba	79	1	1	—	—	—
Haiti (b)	27	8	1	3	2	—
TOTAL	2,519	2,952	3,086	3,120	3,374	3,526

* Source: *Fruit*, 1959 (Commonwealth Economic Committee).
(a) Shipments to Portugal.
(b) Twelve months ending September 30th in year shown.
† Not available.
— Negligible.

TABLE II

World Imports of Bananas by Country
*(in order of importance in 1958)**
Quantity thousand tons

	1938	1954	1955	1956	1957	1958
United States (a)	1,270	1,450	1,440	1,416	1,460	1,490
Federal Republic of Germany	160	180	218	292	337	416
France	176	273	265	262	305	346
United Kingdom	305	289	307	315	314	310
Argentine Republic	165	193	162	150	188	246
Spain	50	86	124	154	157	149
Canada	77	132	132	137	142	144
Italy	26	36	44	46	43	61
Belgium	20	46	50	52	56	60
Netherlands	26	27	33	40	46	51
Sweden	12	42	47	43	42	39
Japan	121	29	24	19	27	36
Switzerland	7	18	20	23	28	33
New Zealand	16	20	27	21	22	32
Hong Kong	—	17	11	18	16	30
Norway	9	7	8	12	28	28
Denmark	6	27	27	25	26	24
Portugal (b)	—	16	16	20	20	20
Austria	2	6	10	11	14	17
Uraguay	13	20	20	13	18	14
Chile	16	24	17	12	12	13
Algeria	5	9	9	8	8	13
Morocco	2	8	10	10	7	10
Syria	—	4	8	10	6	9
Finland	4	5	8	7	8	7
Union of South Africa	5	16	7	8	13	7
Soviet Union	—	—	2	3	2	5
Irish Republic	6	6	7	7	6	5
TOTAL	2,499	2,986	3,053	3,134	3,351	3,615

* Source: *Fruit*, 1959 (Commonwealth Economic Committee).
(a) Converted from count bunch equivalents.
(b) Shipments to Portugal from Maderia.
— Negligible.

TABLE III

*United States: Imports of Bananas**

Quantity thousand bunches

	1938	1954	1955	1956	1957	1958	1959
Ecuador	1,160	13,395	16,648	16,164	16,697	16,165	22,934
Honduras Republic	9,889	7,976	6,470	10,860	9,839	10,899	9,783
Panama	6,353	6,747	7,336	6,730	8,121	8,287	8,424
Costa Rica	4,074	7,227	6,546	4,582	5,552	5,719	4,527
Guatemala	9,175	3,558	3,562	3,540	2,802	3,441	3,795
Dominican Republic	420	1,617	1,627	1,023	1,410	2,016	2,128
Mexico	15,497	2,749	1,780	936	2,160	1,207	1,354
Colombia	3,751	3,636	2,400	1,827	684	803	1,040
Nicaragua	2,082	566	445	234	117	103	105
Cuba	4,227	93	41	22	21	13	21
Haiti	1,443	278	55	161	90	22	6
Other Countries	1,172	119	105	150	243	96	97
TOTAL	59,243	47,961	47,015	46,229	47,736	48,771	54,214

* Source: *Fruit Intelligence*, 1954, **3**, No. 12, 26; *ibid.* 1960, **10**, No. 2, 29.

TABLE IV

United Kingdom: Imports of Bananas

Quantity thousand tons

	1938	1954	1955	1956	1957	1958	1959
Jamaica	232·8	138·5	136·5	145·7	145·6	122·8	134·6
Windward Is.	(a)	(a)	21·8	34·3	47·5	58·4	88·7
Nigeria	5·6	75·8	68·9	67·1	68·8	73·7	57·8
Canary Is.	7·8	17·0	43·3	35·4	20·2	26·3	29·4
Spanish West Africa	(a)	1·3	3·2	7·7	11·3	9·5	8·9
Brazil	30·6	33·1	29·4	16·8	10·1	10·6	7·2
Trinidad	(a)	(a)	0·4	3·2	7·2	4·6	5·0
Ghana	1·2	0·3	0·6	0·7	0·9	1·7	1·4
Other Countries	13·8	23·4	2·6	4·1	2·2	2·3	4·0
TOTAL	305·0	289·4	306·7	315·0	313·8	309·9	337·0

* Source: *Fruit Intelligence*, 1957, **6**, No. 9, and *ibid*, 1960, **9**, No. 9, 8 and *Fruit*, 1959.
(a) Not available, included, if any, with 'other countries'.

TABLE V

Imports of Bananas into Selected European Countries

Quantity thousand tons

	1954	1955	1956	1957	1958	1959
Federal Republic of Germany						
Total	180·3	218·4	291·6	336·8	415·9	423·4
of which from:						
Ecuador	79·0	89·3	109·3	149·8	238·1	212·9
Colombia	48·4	70·6	101·8	103·8	108·7	133·8
Honduras Republic	(a)	21·9	18·3	11·6	19·6	32·9
Dominican Republic	(a)	(a)	9·3	6·4	14·1	15·9
Guatemala	41·8	20·3	33·1	46·7	13·0	15·5
Canary Is.	8·4	10·3	11·5	10·1	5·7	5·0
French Cameroons	0·3	0·3	1·8	2·2	5·1	1·5
Congo	1·8	4·8	4·6	3·8	2·1	1·4
France						
Total	273·0	267·0	262·0	304·7	345·7	336·0
of which from:						
Martinique	55·0	51·0	70·0	89·4	99·2	123·6
Guadeloupe	76·0	68·0	59·0	65·6	85·2	102·3
French Cameroons	50·0	52·0	51·0	65·3	61·9	49·8
French West Africa / Guinea	90·0	92·0	78·0	79·3	97·9	34·0 / 24·9
French Eq. Africa	(a)	(a)	(a)	0·9	0·9	1·0
Spanish West Africa	(a)	(a)	(a)	3·8	0·3	0·1
Belgium						
Total	45·9	50·0	51·7	56·2	60·2	60·3
of which from:						
Ecuador	(a)	(a)	(a)	19·3	26·6	23·9
Colombia	(a)	(a)	(a)	19·4	15·9	14·0
Congo	(a)	(a)	(a)	11·1	8·9	12·5
Netherlands						
Total	27·2	32·9	40·1	45·7	50·9	56·1
of which from:						
Colombia	8·6	20·2	24·2	21·9	20·9	17·9
Ecuador	7·3	6·2	6·3	8·8	12·4	13·7
Belgium	2·1	4·6	6·4	6·7	7·8	8·7
Dominican Republic	(a)	(a)	(a)	4·1	5·0	7·5
Honduras Republic	4·4	(a)	(a)	0·7	3·4	5·4
Guatemala	4·7	1·0	0·6	3·4	0·3	2·2
Federal Republic of Germany	(a)	(a)	1·6	0·3	0·2	0·5

* Source: Various issues of *Fruit Intelligence*.
(a) Not available.

Notes

Spontaneous Heating and Combustion of Oilseed and Oilcake.—The Institute is occasionally asked for advice concerning fire risks associated with the storage of oilseeds and oilcakes. A recent inquiry, which specifically concerned niger seed resulted in the discovery of unpublished information of sufficient interest to warrant review.

Following a fire on the Continent, believed to be caused by heat generation in niger seed flakes, an oil milling establishment approached its assignment to mill this seed with caution. In a preliminary experiment some 23 tons of the seed were processed and divided into two piles of about 9 tons each (a) with an oil content of about 6·5 per cent ; moisture content 2·5 per cent.; and (b) with an oil content of 5 per cent ; moisture content of 12 per cent. The temperature of pile (a) rose to about 22°C.—26°C. and then dropped steadily, whereas with the wet pile (b) the temperature rose very rapidly to about 45°C., after which a very gradual decline set in. It was therefore decided to crush the seed dry. However, in the subsequent processing of some 260 tons, there were several remarkable occurrences. Thus, in a heating pan which had been used for the seed and which was subsequently emptied, seed residues left behind ignited after about two hours, although the steam jacket on the pan had been turned off. Flakes from an early stage of processing with a somewhat high oil content (approximately 9 per cent.) were drawn off into bags while still warm, with a view to reprocessing later. It was found after about a day that some one-third of these new bags displayed fire marks where they had been in contact with one another. Then a pile of 174 tons of flakes (5·9 per cent. fat, 2·5 per cent. moisture) were stacked at a temperature of approximately 30°C. The pile had about 110 bags to a layer and was 30 layers high with two ventilating tunnels. Considerable heating occurred in this pile, especially at a distance of about 1 metre from the ventilating channels, where temperatures in excess of 160°C. and considerable charring was observed. These findings can be summarized as follows:

Location	Oil content of Flakes	Initial Temperature	Observations
Heating pan .	38 per cent.	(Steam heated pan)	Fire observed after two hours.
Bags . . .	9 per cent.	50°C.	Scorching observed after about two days.
Large pile of sacks of flakes (170 tons)	6 per cent.	30°C.	Scorching observed after nine days.
Small pile of flakes	6 per cent.	22°C.	No fire and only slight heat generation.

Detailed observations such as those recorded above are rare. Miller and Thompson[1] described two cases of spontaneous heating with soya beans. This paper, together with a study published elsewhere[2] seem to indicate that spontaneous heating in soya beans can be due to three well defined causes:

(a) A stage of biological heating, due to the growth of moulds (e.g. species of *Aspergillus*) where temperatures up to about 55°C. result. Further increases in temperature cause the death of the moulds.

(b) Heating due to the growth of thermophilic bacteria when temperatures up to at least 80°C. can result. Since most of these bacteria require a high relative moisture content for proliferation this cause is seldom found in normal oilseed milling.

(c) Heating due to purely chemical reactions. It is suggested by Miller and Thompson (*loc. cit.*) that with soya beans the Maillard reaction, and similar protein-sugar interactions, possibly catalysed by the presence of metals is a major cause of the spontaneous chemical heating. The initial microbiological heating is not necessary to subsequent chemical heating.

Niger seed oil varies in composition according to the climatic conditions under which the seed is grown. The main component in the oil is an oleo dilinolein and its fatty acids contain from 30 to 74 per cent. of linoleic acid. The oil is thus similar to that of tobacco, poppy, sunflower and safflower seed oils and it is noteworthy that the risk of spontaneous heating in the carriage of sunflower seed cake is well recognized. Another vegetable oil associated with the risk of fire is linseed oil which contains about 15 per cent. of linoleic and about 55 per cent. of linolenic acids.

Apart from differences in the chemical constitution of oils which affect their speed of oxidation, the presence of metals which can act as catalysts, of organic compounds such as antioxidants, or of oxidation products promoting further oxidation, are important factors which need consideration. Radford[3] has shown that steel wool saturated with linseed oil is subject to spontaneous combustion when the boiled oil is used, but not when raw or refined oil is employed. However, even palm kernels, which contain but little unsaturated fatty acids, can show spontaneous heating.[4]

Quite evidently, further work is required before the causes of the spontaneous heating of oilseeds can be satisfactorily elucidated. In view of its importance it is surprising that so little scientific study has been devoted to this subject.

W.D.R.

(1) *J. agric. Fd Chem.*, 1954, **2,** 303.
(2) *Cereal Chemistry*, 1946, **23,** 449.
(3) *Paint Technology*, 1956, **23,** 17.
(4) *J. Sci. Fd Agric.*, 1951, **2,** 157-60.

Sudan Jutes.—Following the publication of M. D. ffrench-Mullen's article on jute cultivation experiments in British Guiana,* we have received the following most interesting comment on the origin of the strain, E.C.R. 576, from Mr. H. Ferguson, the Director of the Tocklai Experimental Station of the Indian Tea Association at Assam.

'Throughout the Sudan, *Corchorus olitorius* is grown as a vegetable, and, in 1939, I found plants of this species of a height exceptional for local conditions being grown in the Meridi district of Equatoria province in the southern Sudan. I collected seed of this and similar stocks of *Corchorus*, sowed it at the Kagulu Experimental Station in the southern Sudan in the 1939/40 season, rogued each stock and retained seed of each strain thus obtained and selected. Unfortunately, all these stocks were destroyed in a fire soon after harvest. As the 1939/40 trials had shown considerable promise, I obtained in 1940, this time through the agency of a field assistant, further stocks of seed from the Meridi region.

'E.C.R. 576 was a selection from one of these stocks, and, both in the southern and north central Sudan, where it was later tried, proved to be consistently the tallest and heaviest cropper of both local and introduced strains. I myself was of the opinion that, even after selection, it was neither as tall or as uniform as the best stock lost in the fire of 1939. Records of height and weight of stem and retted fibre were kept for a number of seasons from experiments at Kagulu, and were summarized in the annual reports of that station (unpublished). I cannot now recollect whether similar records of the pre-fire 1939 stocks were ever made.

'The other strains of jute of Sudan origin, bearing E.C.R. numbers, were selections of a similar kind either from environments in the southern Sudan similar to that of Meridi or from the central Sudan in the Noba Mountains region. I collected and selected the former in the early 1940s and the latter about 1950.

'The E.C.R. designation refers only to the plant propagation registration number given to all stocks maintained by the Plant Propagation Officer at the Gezira Research Farm (Headquarters of the Research Division of the Sudan Ministry of Agriculture). The original descriptive designations and thus the Kagulu records for each E.C.R. strain, however, would be traceable through the E.C.R. register.'

H.F.

* *Trop. Sci.*, 1959, **I,** No. 4, 231-85 and 1960, **II,** Nos. 1 and 2, 1-35.

Book Reviews

THE WEALTH OF INDIA. RAW MATERIALS. Vol. V. H-K (with index). Chief Editor, B. N. Sastri, xxv + 332 pp. 11 × 9. (New Delhi: The Director General, Council of Scientific and Industrial Research, 1959.)

The present volume in the series* maintains the high standard as a work of reference and for general reading set by previous volumes.

It is profusely illustrated with 179 black and white photographs and diagrams as well as several coloured plates, and refers extensively to the relevant literature on the various topics. An index of names in Indian languages, trade and regional names and common English names is included.

Barley

After a brief introduction describing the morphology, classification and the history of the world cultivation of barley (*Hordeum vulgare* Linn.), a general account of its cultivation in India is given including a description of the diseases by which it may be afflicted.

India is the third largest producer of barley, and, in 1955-6, had an estimated area of 8,155,000 acres under cultivation, which produced 2,721,000 tons. The chief producing areas are located in the Northern States viz., Uttar Pradesh, Rajasthan, Bihar, Punjab and Madhya Pradesh. Comments are made on the low yield per acre of Indian barley, and the methods of storage and marketing are briefly described.

The estimated average annual consumption of Indian barley for various purposes is as follows: human consumption 76 per cent ; livestock feeding 22 per cent ; malting and pearling 1 per cent. Barley for human consumption is seldom used alone, but is generally ground to a flour and mixed with grain and wheat flour for preparing chapatis. A full description of the nutritional aspects of barley is given, including useful figures for the average consumption of Indian barley, the vitamin status, amino-acid make up of the protein, and mineral constituents of barley. A brief description of the use of barley and barley straw as animal feedingstuffs is also given. The section ends with a brief account of the production of barley malt.

Drugs

Several drug plants are included among the items in this volume. Two such dealt with in some detail are *Hyoscyamus* and *Hydnocarpus*; problems of cultivation are considered, together with particular aspects of the chemistry of the active principles. The use of hydnocarpus or chaulmoogra oil and derivatives for the relief of leprosy is discussed, but—commendably—attention is drawn to the fact that these preparations have yielded place to synthetic sulphone drugs as the treatment of choice for this distressing affliction. Entries on other genera whose members contain alkaloids and similar substances of pharmaceutical interest include *Hedyotis*, *Holarrhena*, *Kopsia* and *Krameria*.

Insects

By a rather liberal interpretation of the term 'raw materials', an article on insects finds a place in this volume. The entry is, in fact, one of the longest, running to over 50 pages, and is divided into a number of sections, including ones on insect pests of cultivated plants, of trees, of cattle, and of stored products. Beneficial insects, general principles and control methods are also discussed, and there is a short list of the chief insecticides in use today. In addition, several full-page plates illustrate many of the principal insect species, and other figures and diagrams are interspersed throughout the text.

* Previous volumes were reviewed in *Trop. Sci.*, 1959, **I**, No. 3, 220; *Colon. Pl. Anim. Prod.*, 1952, **III**, No. 3, 262; and *Colon. Pl. Anim. Prod.*, 1950, **I**, No. 1 and 4, 78, 326.

Essential Oils

Essential oils of *Hedychium* species are dealt with clearly and accurately.

Extraction of orris oil, concrete and absolute from the *Iris* species such as *I. pallida* is accurately described.

Jasmin (*Jasminum auriculatum*, *J. sambac* and in particular *J. officinale* from *grandiflorum*) is grown in various parts of India for its perfume oils. A brief description is given of the extraction procedures used in Europe for the production of the pomade or the absolute, but of greater interest are the methods described for obtaining native perfumes. One of these is a modified enfleurage process in which the fresh jasmin flowers are spread in alternate layers with *Sesamum indicum* seeds on the floor of a cemented pit. Exhausted flowers are replaced by fresh flowers after every 10-12 hours until the seeds are saturated with the perfume. A perfumed oil called *Sire Ka tel* is then expressed from the seeds in ghanies. A jasmin attar is made by distilling the flowers in earthenware vessels and absorbing the vapours in sandalwood oil.

Juniper species yield various essential oils which are clearly described. *Juniperus communis* gives the fruit oil (Juniper oil) which is largely used in compounded gin flavours, liqueurs and cordials. *J. virginia* and *J. procera* yield the cedarwood oils used in soap perfumery and in microscopy.

Fruit

The Walnut (*Juglans regia*) occurs in a number of hilly regions in India but the important State for the production of the commercial crop is Kashmir. On account of the pressure on arable land the trees are mostly grown on the poorer soils, on terraces or near dwellings. Seedlings are planted and the use of selected varieties on any appreciable scale is still to be developed. Indeed the problems presented in crop improvement are underlined by the statement that in certain regions the planting of walnuts is considered to be inauspicious. Only seedlings that come up naturally are allowed to grow and this has resulted in the preponderance of poor types of trees. A large proportion of the best quality nuts of the commercial crop is exported. As regards the timber, although there is some use of the wood for furniture in Kashmir, most of the output is taken by the Indian Ordinance Department for gunstocks.

The sweet potato (*Ipomoea batatus*) is grown throughout India and a comprehensive monograph provides information regarding production in the various states, the varieties grown, cultural details and the utilization of the crop. Sweet potatoes cultivated in India may be divided into two main groups broadly distinguished by the colour of the skins of the tubers which are white or red. In Northern India the red varieties are generally preferred but in Southern India the preference is for the white skinned kinds. Excellent coloured illustrations are provided of typical white and red varieties.

Fibres

The reviewer's first impression was that the sections on *Hibiscus cannabinus* and *H. sabdariffa* would be very useful as sources of references relating to kenaf and roselle fibres. A more detailed examination caused some modification of this first impression. The reasons for this were: firstly the contributors are not sufficiently critical in that distinction is not made between statements based on the results of experimental evidence and statements which are matters of opinion. For example the statement appears that 'the fibre (kenaf) is coarser, harsher, and more brittle and inflexible' (than jute). Comparative figures are given for the fineness of kenaf, roselle and jute, but no data is given in the volume or in the references to support the statements relating to the harshness, brittleness and flexibility of the fibres. The statement is made that kenaf fibre is more resistant to rot than jute. This is not supported in the references given, although the claim is made that *decorticated* kenaf does not contain micro-organisms that remain on retted fibre and is therefore less likely to develop mildew.

Secondly, more recent figures for the physical properties of kenaf, and roselle fibre are available (H. P. Stout and J. A. Jenkins, *Ann. Sci. Text, Belges*, 1955, No. 4, 231) and would have been well worth including.

A minor criticism concerns the use of Indian measures. On page 79 the seed rate for kenaf is given as '10-15 seers per acre'. This is hardly a satisfactory measure to use particularly since, according to the Shorter Oxford English Dictionary, 'Seer' is 'A denomination of weight varying in different parts of India from over 3 lb. to 8 oz. (usually = 2 lb.)'.

Plants for papermaking

Whilst this volume does not contain any entry specifically on pulp and paper production, a number of the plants mentioned have been tried as a source of pulp. The plants with entries under this heading include *Helianthus annuus*, *Helicteres isora*, *Heteropogon contortus* and *Imperata cylindrica*. Information is given on the chemical composition of the plant from a paper-making viewpoint together with the dimensions of the ultimate fibres and the type of paper that can be produced. The data given are, in fact, very good precis of almost all the reported work done on these plants.

Hibiscus manihot is mentioned as a source of mucilage which can be used as a fibre dispersant.

Oilseeds

Oilseeds which are dealt with in the present volume include species of *Helianthus*, *Hevea*, *Hydnocarpus*, *Jatropha* and *Joannesia*. Apart from *Hydnocarpus*, which is used for the treatment of leprosy, the remaining species are not exploited commercially to any extent in India as sources of oil. It is interesting to note that sunflower (*Helianthus annuus*) has been grown experimentally in India, including various Russian varieties. Some of the latter which have been developed in U.S.S.R. yield seeds with thin husks containing an average of 40 per cent. of fat as compared with the average of about 28 per cent. usually found. The acreage yield from some of the Russian varieties has been high. In spite of this it has been concluded that sunflower cannot compete economically in India with groundnut, safflower or niger seed. The article which records this finding is of considerable general interest.

In contrast the article dealing with rubber seed (*Hevea brasiliensis*) as a source of oil contains phrases such as 'The press cake or extracted meal is used as a fertilizer or feed for stock' which suggest that the seed is actually processed in India today. However, the reviewer knows of no country where rubber seed is now processed on any appreciable scale commercially as a source of oil. It appears probable the information provided in the present article indicates what might be, rather than what is, practised today. If this conclusion is correct some discussion of the difficulties that have been experienced and that have hitherto prevented the development of rubber seed as an oilseed would be of value and should be included in future editions. If however, this seed is processed even on a small scale in India some statistics would be of considerable interest. This article is disappointing as it seems merely to reproduce, in the main, information more readily available elsewhere without discussing in any detail the position of rubber seed as a source of oil in India.

Various species of *Jatropha* yield oleaginous seeds. The best known is that from *J. curcus*, commonly known as Physic nut, but this is utilized mainly for its purgative properties rather than as a source of oil for general industrial use. Three other species of *Jatropha* also grow in India and yield oleaginous seeds with similar properties to the Physic nut.

Joannesia princeps is a handsome medium-sized tree which is cultivated in Indian gardens. It belongs to the same family as *Jatropha* and also yields a purging oil and nut.

A.J.F., L.H.G.-B.,
C.G.J., E.H.G.S.,
G.B.P., E.R.P., and
W.D.R.

FERTILIZER USE: NUTRITION AND MANURING OF TROPICAL CROPS. By the late Dr. A. Jacob and Dr. H. V. Uexküll. Translated by C. L. Whittles. 2nd revised edition. 617 pp., $7\frac{3}{4} \times 4\frac{3}{4}$. (Germany: Verlagsgesellschaft für Ackerbau, 1960.)

Dr. A. Jacob died shortly before the present English edition of this book was printed. The German edition was first published in 1958 and it is unfortunate that Dr. Jacob did not live to hear the English readers' praises which must surely be given to him and also to his co-worker, Dr. Uexküll, for their gargantuan task in assembling and editing the widely-scattered literature on the nutrition of tropical crops.

It is without doubt the most important book which has appeared on the subject. The size and format is pleasing and the photographs dealing with the many aspects of tropical agriculture are excellent. All the major tropical crops are individually dealt with, together with some which are not strictly tropical, e.g. apples, pears, grapes, wheat, etc. Of interest are the many tables, analyses, conversion factors, statistics and miscellaneous information provided in Part III. The book ends with a selected bibliography on plant nutrition, soils and fertilizers and there is an author index. A serious fault is the absence of a subject index.

The book should be useful to agriculturists in the tropics and also those fertilizer manufacturers trading overseas.

P.C.C.

INTRODUCTION TO AGRICULTURAL ECONOMIC ANALYSIS. By C. E. Bishop and W. D. Toussaint. 258 pp., 9 × 6. (New York and London: John Wiley and Sons Inc., 1958.) Price 42*s*.

This book states the basic elements of economic analysis as applied to problems of agricultural production and marketing. Examples have been drawn from studies of a wide range of problems and from many areas of the United States of America.

The first section, which summarizes the broad theme, explains the need for efficient organization to ensure economic growth and a smoothly functioning farming economy. It indicates the problems involved in determining what and how much to produce, what methods of production to use, and when and where to buy and sell.

The second section deals in detail with the relationship between input and output. A farmer is, for example, not only concerned with the fact that nitrogen influences corn yield. He needs to know how much nitrogen to use and how much corn he can expect to receive from various quantities of nitrogen. The possibilities of reducing the cost of production by changing the combination of inputs, e.g. fertilizer, seed, petrol, weed spray, labour, when the prices of inputs vary, are also pointed out. In addition, the choice of products and the reasons for specialization in the output of one product by some farmers and for diversification of production by others are discussed. Examples of cost analyses to determine whether a farm is profitable, what size of plant should be constructed and what level of output is necessary before it pays to purchase some machine are given.

Part three is concerned with consumption and examines the reasons for changes in demand. Price elasticity is defined and illustrated in typical demand curves. Long-term changes in *per capita* consumption patterns are also illustrated and indicate the direction to be followed by agricultural production in the future. The section also deals with the importance of international trade to agriculture.

Part four is concerned with the effects of technological improvements on food and fibre production. During the period 1930-50, there was a 39 per cent. increase in agricultural output in the United States with a 1 per cent. increase in input. The authors point out, however, that technological advances which enable farmers to produce more with the same input do not necessarily increase their net revenue, because increased production exerts a downward pressure on prices which may outweigh the reduced cost of production. Even so, the farmer will still be well advised to adopt the improvement providing it reduces his cost of production per unit. If he does not, the price he receives will, in any case, fall as a result

of increased production on other farms and his loss of earnings will therefore be less than if he continued to use the old methods. Changes in demand are also studied from the point of view of changes in the numbers and composition of the population and of the growth and distribution of incomes among various sections of the population.

The book illustrates the value of applying theoretical concepts to solve practical farming problems and can be recommended to all concerned with farm management and the marketing of agricultural produce.

M.K.

RECEIVED FOR NOTICE

SOIL AND LAND-USE SURVEYS, No. 8. Report by the Regional Research Centre of the British Caribbean. 26 pp. Maps. 10½ × 8. (Trinidad: The Imperial College of Tropical Agriculture, October, 1959.) Price 12*s*.

Survey No. 8 deals with Jamaica and reports on the soils of the Parish of St. James and on factors affecting land-use in the parish. Some general factors at present operating to the detriment of sound land-use and requiring attention are mentioned and a programme to make possible the best use of land is outlined.

SOIL AND LAND-USE SURVEYS, No. 9. Report by the Regional Research Centre of the British Caribbean. 42 pp. Maps. 10½ × 8. (Trinidad: The Imperial College of Tropical Agriculture, June, 1959.) Price 18*s*.

Survey No. 9 deals with Grenada and points out the island's dependence on too few crops—mainly cacao and nutmegs. The report says that efforts must be made to widen the basis of Grenada's agriculture and suggests that a fairly obvious extra main crop could be coffee. Minor export crops might be pepper, cinnamon, cloves and mangoes. Lines of research to improve the use of land are suggested.

WESTERN NIGERIA. 32 pp. (London: Patrick Dolan & Associates.) Gratis.

The booklet provides a useful survey for business men of the scope and facilities for capital investment in Western Nigeria. It also contains a section dealing with Government policy on foreign capital.

Bibliography

Compiled by Miss V. Clarke

Comprising the more important reports, articles, etc., contained in publications received in the Library for the six months, January to June 1960.

The publications issued by the Governments of the Colonies and Protectorates can be obtained from or through the Crown Agents for Overseas Governments and Administrations, 4 Millbank, Westminster, S.W.1. Applications for Dominion, Northern and Southern Rhodesian Government publications may be made to the Offices of the High Commissioners or Agents-General in London.

Publications of the U.S. Departments of Agriculture and Commerce are obtainable from Superintendent of Documents, U.S. Government Printing Office, Washington 25, *D.C., U.S.A., or from H. M. Stationery Office, London.*

F.A.O. publications are obtainable from the Food and Agriculture Organization of the United Nations, Washington 25, *D.C., U.S.A., or from H. M. Stationery Office, London.*

Agriculture

A Review of Commonwealth Raw Materials. Vol. II. *37th Rep. Commonw. econ. Comm.*, 1960. 412 pp. (London: H. M. Stationery Office, 1960). Price £1 15*s.* 0*d.* net.

Colonial Research 1958-59. Reports of the Colonial Research Council Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee, Colonial Fisheries Advisory Committee, Colonial Medical Research Committee, Colonial Pesticides Research Committee, Colonial Products Council, Colonial Road Research Committee, Colonial Social Science Research Council, Tsetse Fly and Trypanosomiasis Committee, Director, Anti-Locust Research Centre and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. *Cmnd.* 938. 419 pp. (London: H. M. Stationery Office, 1959). Price 6*s.* 0*d.* net.

Report and Accounts, Colonial Development Corporation, 1959. 101 pp. (London: Colonial Development Corporation, 1960).

Report of the Rothamsted Experimental Station for 1959. 288 pp. (Harpenden, Herts.: Rothamsted Experimental Station, 1960). Price 10*s.* post free.

Report, Department of Agriculture, Canada, for the Year ended March 31, 1959. 158 pp. (Ottawa: Queen's Printer, 1959). Price 50 *cents.*

Report of the Department of Agriculture, Province of Alberta, for the Year 1958. 211 pp. (Edmonton: Queen's Printer, 1959).

Report, Indian Council of Agricultural Research, 1956-57. 209 pp. (Delhi: Manager of Publications, India Press, 1959). Price Rs. 5.25, 8*s.* 3*d.*

Scientific Reports of the Indian Agricultural Research Institute for the Year ending 30th June 1957. 136 pp. (Delhi: Manager of Publications, 1958). Price Rs. 7.00 or 11 *sh.*

Report of the Department of Agriculture, Federation of Malaya, for the Year 1958. By P. G. Coleman. 98 pp. (Kuala Lumpur: Government Press, 1959). Price $2.50.

Plant Disease Investigation in the Federation of Malaya. By A. Johnston. *F.A.O. Plant Prot. Bull.*, 1959, **8**, No. 1, 1-4. Diseases of cocoa, citrus, coconut, oil palm, pineapple, rice and tomato.

Quinquennial Report Pakistan Council of Scientific and Industrial Research, 1953-58. 224 pp. (Karachi: Pakistan Council of Scientific and Industrial Research, 1959).

Report of the Department of Agriculture and Stock, Queensland, for the Year 1958-59. 106 pp. (Brisbane: Government Printer, 1959).

Report of the Department of Agriculture, Western Australia, for the Year ended 30th June 1958. 55 pp. (Perth: Government Printer, 1959).

Report, Cawthron Institute for Scientific Research, 1958-59. 44 pp. (Nelson, N.Z.: Cawthron Institute, 1959).

Report East African Industrial Research Organization, 1958-59. 21 pp. (Nairobi: Government Printer, 1959). Price *Sh.* 2.

Report of the Eastern Region Development Corporation, Nigeria, 1957-58. 37 pp. (London: Nigeria Office or Enugu: Eastern Region Development Corporation, 1959).

Report Produce Inspection Division, Ministry of Agriculture, Eastern Region of Nigeria, 1958-59. 29 pp. (Enugu: Government Printer). Price 1*s.* 6*d.* net.

A Guide to Irrigation Farming. By G. Turck. *Rhod. agric. J.*, 1960, **57,** No. 1, 1-45.

Report and Accounts for 1957-58 *of the Tanganyika Agricultural Corporation.* 149 pp. (Dar es Salaam: Government Printer, 1959). Price *Shs.* 16/-.

Report, Department of Agriculture, Tanganyika, 1958. *Part II (Research)*. 33 pp. (Dar es Salaam: Government Printer, 1959). Price *Shs.* 3/50.

Report of the Department of Agriculture, Zanzibar, 1958. 48 pp. (Zanzibar: Government Printer, 1959). Price *Shs.* 2/-.

Results of Field Experiments, Crop and Stock Records and Other Statistics. *Supplement to the Report of the Department of Agriculture, Zanzibar*, 1958. 19 pp. (Zanzibar: Government Printer, 1960). Price *Shs.* 2/-.

Report and Recommendations on the Present Position and Future Prospects of Agriculture in the Zanzibar Protectorate. 36 pp. (Zanzibar: Government Printer, 1959). Price *Shs.* 2/-.

Report of the Department of Agriculture, Mauritius, for the Year 1958. *No.* 30 *of* 1959. 64 pp. (Port Louis: Government Printer, 1959).

Report, Department of Agriculture, British Honduras, for the Year 1958. 99 pp. (Belize: Government Printing Department).

Report on the Agricultural Department, Montserrat, for the Year 1958. 17 pp. (Plymouth: Agricultural Department, 1959).

Report, Agricultural Department, St. Vincent, 1955. 68 pp. (Kingstown: Government Printer, 1960).

Economic Survey of Trinidad and Tobago 1953-58. 124 pp. (Port-of-Spain: Office of the Premier, 1959). Price $1.00.

Report of the Governing Body and Principal's Report, Imperial College of Tropical Agriculture, Trinidad, for 1958-59. 68 pp. (St. Augustine, Trinidad: Imperial College of Tropical Agriculture, 1960).

Agricultural Statistics, The West Indies. Series I. The 1956-58 *Surveys. No.* 3. *The Survey in Nevis.* 24 pp. *No.* 6. *The Survey in St. Lucia.* 29 pp. *No.* 7. *The Survey in Dominica.* 27 pp. (Federal House, Port of Spain: Ministry of Natural Resources and Agriculture, 1960 and 1959). Price 15 *cents* each.

Departmental Report, Hong Kong, by the Director of Agriculture, Fisheries and Forestry for the Financial Year 1958-59. 97 pp. (Java Road, Hong Kong: Government Printer). Price $4.

Report, Department of Agriculture, Forests and Fisheries, Western Samoa, for 1959. 44 pp. (Apia: Department of Agriculture, 1960).

Report of the Agriculture Department, Tonga, for the Year 1958. 39 pp. (Nuku' Alofa: Government Printer, 1959).

Estatística Agrícola, Provincia de Moçambique, 1955. 407 pp. (Lourenço Marques: Imprensa Nacional, 1959).

Yearbook of Agriculture, U.S. Department of Agriculture, 1959. 736 pp. (Washington 25, D.C.: Superintendent of Documents, 1959). Price $2.25.

Agricultural Statistics 1959, *U.S. Department of Agriculture.* 632 pp. (Washington D.C.: Government Printing Office, Superintendent of Documents, 1960). Price $1.75.

The Agriculture of South-East Asia. By J. M. Brown. *Span*, 1960, **3,** No. 2, 64-8.

Beverages

Mineral Deficiency Symptoms of Cacao Grown in Sand-Culture. By R. G. Lockard *et al. Bull. Dep. Agric. F.M.S.*, 1959, *No.* 107. 20 pp. (Kuala Lumpur: Department of Agriculture, 1959). Price $4.00 or 9*s.* 6*d.*

Coppicing Experiments on the Spread and Control of Cacao Swollen-Shoot Disease in Nigeria. By J. M. Thresh and R. M. Lister. *Ann. appl. Biol.*, 1960, **48**, No. 1, 65-74.

Report of the Research Department of the Coffee Board, South India, 1957-58. *Bull. No.* 11. 184 pp. (Balehonnur P.O., S. India: Director of Research, Coffee Board). Price Re. 1.

Coffee in Tanganyika. How Chemicals are used. By H. Sandford. *Span*, 1959, **2**, No. 2, 78-81. Fertilizers; insect pest, weed and fungal control.

Report, Department of Hop Research, South Eastern Agricultrual College, Wye, 1958. 90 pp. (Ashford, Kent: Wye College, 1959). Price 5*s*.

Report, Tea Research Institute of Ceylon, for the Year 1958. 84 pp. (Talawakelle: Tea Research Institute, 1959).

Propagation of Tea Cuttings. By T. Visser *et al. Bull. Tea Res. Inst. Ceylon, N.S.*, 1959, No. 1. 40 pp.

Report of the Indian Tea Association, Scientific Department, 1958. 415 pp. (Calcutta: Tocklai Experimental Station).

Report on a Tour of the U.S.S.R. and Seven East European Countries—Summer 1958. By N. G. Gokhale. *Memor. Tocklai exp. Sta. No.* 25. 30 pp. (Calcutta: Tocklai Experimental Station, 1958). Russian teas, specifications, machinery.

Elementary Notes on Tea Manufacture. Part I. Withering. By R. Child. *Pamphl. No.* 18, *Tea Research Institute of East Africa*, 1960. 16 pp.

Report, Tea Research Institute of East Africa, for the Year 1958. 49 pp. (Nairobi: East African Standard Ltd., 1959).

Cereals

Grain Crops. A Review of Production, Trade and Consumption relating to Wheat, Wheat Flour, Maize, Barley, Oats, Rye and Rice. *Publ. Commonw. econ. Comm.*, 1959. 200 pp. (London: H. M. Stationery Office, 1959). Price 10*s*.

Agricultural Mechanization. The Cleaning and Sorting of Grain. By N. Ruzicic. *U.N. Publ.* AGRI/MECH/13. Sales No.: 59. II. E./Mim. 16, 1959. 25 pp. + figs. Price $0.25, 1*s*. 9*d*., 1 *S.f.*

Review of Research for the Period January 1955—*December* 1957, *West African Maize Research Unit*. 54 pp. (Ibadan: Fed. Dep. Agricultural Research).

Mineral Nutrition of the Rice Plant in Malaya with Special Reference to Penyakit Merah. By R. G. Lockard. *Bull. Dep. Agric. F.M.S. No.* 108, 1959. 148 pp. (Kuala Lumpur: Department of Agriculture, 1959). Price $6.00, 14*s*.

An Investigation into Storage Problems of Rice in Sierra Leone. By P. F. Prevett. *Colonial Research Studies No.* 28, 1959. 52 pp. (London: H. M. Stationery Office, 1959). Price 16*s*. 0*d*. net.

Report of the West African Rice Research Station, 1959. 31 pp. (London: Crown Agents, 1959). Price 2*s*.

Drugs

A Phytochemical Register of Australian Plants. *Publ. C.S.I.R.O. Aust. Vol. I*, 1959. 294 pp.

Isolation of Reserpine from *Rauwolfia* Roots. By C. K. Atal. *Indian J. Pharm.*, 1959, No. 12, 339-41.

Rauwolfia Number. *Pakist. J. sci. Res.*, 1959, **2**, Nos. 2-3. 196 pp. Papers on chemistry, cultivation and pharmacology of *Rauwolfia serpentina* with bibliography.

Steroidal Sapogenins and Derived Steriod Hormones. By M. E. Wall. *Amer. Perfum.*, 1960, **75**, No. 4, 63-73.

Alkaloids of Calabash-Curare and *Strychnos* Species. By A. R. Battersby and H. F. Hodson. *Quart. Rev. chem. Soc., Lond.*, 1960, **14**, No. 1, 77-103.

Essential Oils

Essential Oils and Aromatic Chemicals. A Symposium. *Publ. Coun. sci. ind. Res., India*, 1958. Price Rs. 10.00.

Instrumental Analysis of Essential Oils and Related Products. By E. E. Langenau and J. A. Rogers. *Amer. Perfum.*, 1960, **75**, No. 3, 38-48.

Terpenoids XX. Examination of Costus Root Oil. By A. Paul *et al. Perfum. essent. Oil Rec.*, 1960, **51**, No. 3, 115-20.

Fibres

Industrial Fibres. A Review of Production, Trade and Consumption relating to Wool, Cotton, Silk, Flax, Jute, Sisal, and Other Hemps, Mohair, Coir, Kapok, Rayon and Other Man-made Fibres. *Publ. Commonw. econ. Comm.*, 1960. 236 pp. (London: H. M. Stationery Office, 1960). Price 10*s.* net.

Cotton and Allied Textile Industries. *Publ. International Federation of Cotton and Allied Textile Industries.* 51 pp. (Manchester: International Federation of Cotton and Allied Textiles Industries, 1959).

Report, British Cotton Growing Association for the Ten Months ended 31st October 1959. *No.* 191. 44 pp. (Manchester: British Cotton Growing Association, 1960).

Progress Reports from Experiment Stations, Season 1958-59. Aden Protectorate. 25 pp. Republic of the Sudan. 35 pp. Uganda. 75 pp. *Publ. Empire Cotton Growing Corporation,* 1960. (London: Empire Cotton Growing Corporation, 1960). Price 7*s.* 6*d.* per seasonal set.

Cotton in India. By B. L. Sethi. *Span,* 1960, **3,** No. 1, 18-21.

Report of the West Indian Sea Island Cotton Association (Incorporated) 1959. 14 pp. (Manchester: Advisory Committee in England of the West Indian Sea Island Cotton Association).

Market Survey on Cotton Textiles in Switzerland. *Market Survey Series No.* 24. *Min. Comm & Ind., India.* 24 pp. (Simla: Government Press, 1959).

Cotton Production in Africa—Trends and Prospects. By H. G. Porter and T. R. Richmond. *Foreign agric. Rep. No.* 117, 1960. 40 pp. (Washington: U.S. Dep. Agric., 1960).

Cotton Insects. By J. C. Gaines. *Bull. Tex. agric. Exp. Sta. No.* 933, 1959. 16 pp.

Report, Indian Central Jute Committee. The Technological Research Scheme for 1957-58. 47 pp. (Calcutta: Indian Central Jute Committee, 1959).

Scirpus-Kulturen. By K. Seidel. *Arch. f. Hydrobiol.*, 1959, **56,** No. 1-2, 58-92. Cultivation and biology of *Scirpus lacustris.*

Report of the Tanganyika Sisal Growers' Association, Sisal Research Station, for the Year 1958. 36 pp. (Tanga: Tanganyika Sisal Growers' Association).

The Textile Industry in Europe. 5th Year. Trends in Economic Sectors. *Publ. O.E.E.C.* 106 pp. (Paris: O.E.E.C., 1959). Price 6*s.*, $1.00, 400 *Ff.*, 4 *FS. DM* 3.40. Statistical study, 1958: trend in 1959.

Fish

Report of the Fisheries Division, Ministry of Food and Agriculture, Ghana, 1958. 23 pp. (Accra: Government Printing Department (Publications Branch), 1960). Price 3*s.* 6*d.*

Administration Report of the Department of Fisheries, Madras, for the Year 1957-58, 188 pp. (Madras: Controller of Stationery, 1959). Price 3 *R.*

Report of the Chief Secretary on the Fisheries of New South Wales for the Year ended 30th June 1958. *No.* 19. 47 pp. (Sydney: Government Printer, 1959). Price 4*s.*

Report, East African Fisheries Research Organization, 1959. 46 pp. (Jinja, P.O. Box 343: East African Fisheries Research Organization, 1960).

Report of the Lake Victoria Fisheries Service, 1958-59. 31 pp. (Kampala: Uganda Argus Ltd., 1959). Price *Shs.* 4/-.

Report of the Game and Fisheries Department, Uganda Protectorate, for the Period 1st July 1957 *to 30th June* 1958. 96 pp. (Entebbe: P.O. Box 33: Government Printer, 1959). Price *Shs.* 6/50.

Report of the Fisheries Branch, Mauritius. No. 27 *of* 1959. 14 pp. (Pointe aux Sables: Fisheries Officer, 1959).

Halibut—Observations on its Size at First Maturity, Sea Ratio and Length/Weight Relationship. By B. B. Rae. *Marine Research,* 1959, *No.* 4, *Publ. Scottish Home Department.* 19 pp. (London: H. M. Stationery Office, 1959). Price 7*s.* 6*d.*

Fodders

Grasses in Agriculture. By R. O. Whyte *et al. F.A.O. agric. Studies.* No. 42, 1959. 416 pp. Price U.S. $4.00 or 20*s.*

Détermination de la Digestibilité des Herbages Frais. By A. Scaut. *Publ. Inst. nat. agron. Congo belge, Sér. sci. No.* 81, 1959. 86 pp. Price 100 *F.*

FOODSTUFFS

Food Investigation, 1958. *Rep. Low Temp. Res. Sta. & Ditton Lab., Dep. sci. industr. Res.* (London: H. M. Stationery Office, 1959). Price 3*s.* net.

Dairy Produce. A Review of Production, Trade, Consumption and Prices relating to Butter, Cheese, Condensed Milk, Milk Powder, Casein, Eggs, Egg Products and Margarine. *Publ. Commonw. econ. Comm.*, 1960. 133 pp. (London: H. M. Stationery Office, 1960). Price 7*s.* 6*d.*

Report, British Society for the Promotion of Vegetable Research, 1959. 63 pp. (Wellesbourne, Warwick: National Vegetable Research Station, 1960).

Evaluation of Protein Nutrition. A Report of the Food and Nutrition Board. *Publ.* 711, *National Academy of Sciences National Research Council.* 61 pp. (Washington, D.C.: National Academy of Sciences, 1959).

Potato Production. By V. J. Montague *et al. Rhod. agric. J.*, 1960, **57**, No. 1, 52-68.

Guide de Culture Potagère. *Bull. Dep. Agric. Mauritius, No.* 92. 37 pp. (Port Louis: Government Printer, 1959). Price Re. 1. Guide to the cultivation of tropical vegetables.

FORESTRY

Administration Report of the Conservator of Forests, Ceylon, for 1958. 33 pp. (Colombo: Government Publications Bureau, 1959). Price 2/00 *Rs.* Postage 35 *cents.*

Report of the Director of Forests, Queensland, for the Year 1958-59. 70 pp. (Brisbane: Government Printer, 1959).

Report, Forests Commission, Victoria, for 1958-59. 33 pp. (Melbourne: Government Printer, 1959). Price 2*s.*

Report on the Forest Administration of the Western Region of Nigeria for the Year 1957-58. *Sess. Pap. No.* 12 *of* 1959. 38 pp. (Ibadan: Government Printer, 1959). Price 1*s.*

Report, Forestry Department, British Guiana, for the Year 1958. 35 pp. (Demerara: B. G. Lithographic Company, Ltd.).

Report, Forest Department, British Honduras, for the Year 1958. 24 pp. (Belize: Printing Department).

Report of the Forest Department, Sarawak, for the Year 1958. 48 pp. By F. G. Browne. (Kuching: Government Printing Office, 1959). Price $2 post free.

Tropical Silviculture. Volume I. By I. T. Haig *et al.* 190 pp. *Volume II.* By F. H. Landon *et al.* 415 pp. *Volume III.* By L. Bégué *et al.* 101 pp. *F.A.O. Forestry and Forest Products Studies, No.* 13, 1957 and 1958. Price *Vol. I*, U.S. $2.00, 10*s.* *Vol II*, U.S. $4.00, 20*s.* *Vol. III*, U.S. $1.00, 5*s.*

FRUIT

Report of the East Malling Research Station, 1st October 1958 *to 30th September* 1959. 144 pp. (Maidstone, Kent: East Malling Research Station, 1960). Price 17*s.* 6*d.* or $2.50. Post free.

Proceedings of the International Symposium on Origin, Cytogenetics and Breeding of Tropical Fruits. Special Symposium Number. *Indian J. Hort.*, 1958, **15**, Nos. 3 and 4. 286 pp.

Report of the Australian Canned Fruits Board for 1958-59. 32 pp. (Melbourne: Australian Canned Fruits Board, 1959).

Australian and South African Canned Deciduous Fruit Industries. By F. C. Elliott. *Foreign Agric. Serv.*, M61, 1959. 18 pp. (Washington: U.S. Dep. Agric., 1959).

Progrès et perspectives nouvelles dans le traitement frigorifique des produits d'origine végétale. By R. Ulrich. *Fruits d'outre Mer*, 1959, **14**, No. 10, 407-13.

Report of the Banana Board Research Department, Jamaica, 1957-58. 44 pp. (Kingston: Banana Board Research Department, 1959).

Banana Growing in Israel. By Sh. Smirin. *Trop. Agriculture, Trin.*, 1960, **37**, No. 2, 87-95.

Mozambique Citrus. *Internat. Fruit World*, 1960, **19**, No. 1, 277-84.

The Chemical Constituents of Citrus Fruits. By J. F. Kefford. *Advances in Food Research, Vol.* 9, 285-372. *Publ. Acad. Press*, 1959.

Diseases and Pests of Date Palm in the Sahara and North Africa. By A. Calcat. *F.A.O. Plant Prot. Bull.*, 1959, **8,** No. 1, 5-10.

Growing Dates in the United States. By R. W. Nixon. *Agric. Inform. Bull. No.* 207, 1959. 50 pp.

California Macadamia Society Yearbook, 1959. *Vol.* 5, 87 pp. (Carlsbad, California: Secretary, California Macadamia Society, 1228, Las Flores Drive).

Processing and Canning Mango Nectars. By F. Sánchez-Nieva *et al. Bull. P. R. agric. Exp. Sta., No.* 148. 23 pp. (Puerto Rico: Agricultural Experiment Station, Río Piedras, 1959).

The Dehydrofreezing of Pineapples. By H. B. van der Merwe. *Food Ind. S. Afr.*, 1960, **12,** No. 9, 23-25.

Pasificación de Uvas sin Pepita. By L. Hidalgo and M. R. Candela. *Bol. Inst. Invest. Exp. agron. for., Madr.*, 1959, **19,** No. 41, 219-69. (In Spanish). Preparation of seedless raisins in Spain.

Fungicides

Handbook of Toxicology. *Volume V.* Fungicides. By E. F. Davis *et al. Publ. National Academy of Sciences, National Research Council, U.S.A.*, 1959. 242 pp.

Insect Pests and Insecticides

Report of the Colonial Pesticides Research Committee, 1958-59. Pp. 261-80. (London: Colonial Pesticides Research Committee, 1959).

Tropical Stored Products Information, No. 1. 17 pp. (Slough: Pest Infestation Laboratory).

A Guide to Insecticide Formulations. By J. W. Harrison. *Span*, 1958, **1,** No. 3, 30-2.

Estimating Residual Insecticides on Wall Surfaces. By A. V. de Courcy. Field Resistance to Organo-Phosphorus Insecticides. By J. C. Felton. Aldrin, Dieldrin and Endrin: Effects on Soil Micro-organisms. By A. M. H. Sanger. *Span*, 1960, **3,** No. 1, 30-2, 33-6, 37-9.

Handbook of Toxicology. *Volume III.* Insecticides. 854 pp. By W. O. Negherbon. *Publ. National Academy of Sciences, National Research Council, U.S.A.*, 1959. 854 pp.

Proceedings and Papers of the Twenty-sixth Annual Conference of the California Mosquito Control Association, Inc. 91 pp. (P.O. Box 629, Turlock, California: California Mosquito Control Association, Inc., 1958).

Formulation of Pesticides. By S. H. McAllister. *Agric. Chemic.*, 1960, **15,** No. 3, 35-8.

Pesticide Residue Conference, Jan. 19-20, 1959, Washington. *Publ. U.S. Dep. Agric.* 46 pp. Papers and discussions on various residue problems.

Insecticide Resistance in Arthropods. By A. W. A. Brown. *Wld Hlth Org. Mon. Ser.*, 1958, *No.* 38. 240 pp. Price £1 5*s.*, $5.00, *Sw. fr.* 15.

Insecticide Resistance and Vector Control. Tenth Report of the Expert Committee on Insecticides. *Wtd Hlth Org. techn. Rep. Ser.*, 1960, *No.* 191. 98 pp. Price 5/1, $1.00, *Sw. fr.* 3.

Subtropical Fruit Pests. By W. Ebeling. *Publ. University of California, Division of Agricultural Sciences*, 1959. 436 pp. Price $7.00.

Microbial Insecticides—and their Future. By G. Decker. *Agric. Chemic.*, 1960, **15,** No. 1, 30-3, 93.

Samenstelling en Eigenschappen van Rotenon—houdende *Mundulea* Bast. (Composition and Properties of Rotenone—containing *Mundulea* Bark). By W. Spoon and F. E. Loosjes. *Ber trop. Prod. Kon. Inst. Amst.* No. 268, 1959. 10 pp. Reprint from *Tijdschr. PlZiekt.*, 1959, **65,** 79-88.

Phosdrin, A New Insecticide. By A. G. Richardson. *Span*, 1958, **1,** No. 2, 28-30.

Report of the Pyrethrum Board of Kenya, 1st April 1958 *to 30th June* 1959. 24 pp. (Nakuru: Pyrethrum Board of Kenya, 1959).

Livestock and Animal Products

Report, British Leather Manufacturers' Research Association, 1958-59. 81 pp. (Egham, Surrey: British Leather Manufacturers' Research Association, 1959).

Meat. A Review of Production, Trade, Consumption and Prices relating to Beef, Live Cattle, Mutton and Lamb, Live Sheep, Bacon and Hams, Pork, Live Pigs, Canned Meat, Offals, Poultry-Meat. *Publ. Commonw. econ. Comm.*, 1960. 120 pp. (London: H. M. Stationery Office, 1960). Price 7*s.* 6*d.*

Manures

The Manuring of Coffee, Cocoa, Tea and Tobacco. By F. J. E. van Dierendonck. *Publ. Centre d'Etude de l'Azote, No.* 3. 205 pp. (Geneva: Centre d'Etude de l'Azote, 1959).

Fertilisers in Tropical Agriculture. By J. G. de Geus. *Span*, 1960, **3**, No. 2, 60-3.

Oils, Oilseeds and Waxes

Report of the Literature Review Committee. Annual Review of the Literature on Fats, Oils and Detergents. Part I. By I. I. Rusoff *et al. J. Amer. Oil Chem. Soc.*, 1960, **37**, No. 5, 223-42.

West Africa's Fats and Oils Industry. By C. C. Spilsbury. *For. agric. Serv.*—M62. 42 pp. (Washington: U.S. Dep. Agric., 1959).

Report of Coconut Research Board of the Coconut Research Institute, Ceylon, for 1958. *Sess. Pap.* XXI, 1959. 87 pp. (Colombo: Government Publications Bureau, 1959). Price *Rs.* 2.20. Postage 35 *cents.*

Coconut Situation, 1959, *No.* 2. *F.A.O. Publ.* 28 pp.

La Ruggine dell'Arachide. (Rust Disease in Groundnut). By E. Castellani. *Olearia*, 1959, **13**, No. 11/12, 261-70.

Report of the West African Institute for Oil Palm Research, 1958-59. 140 pp. (Benin City, Nigeria: West African Institute for Oil Palm Research, or Crown Agents). Price 2*s.* 6*d.*

Etudes pour un Projet de Propagande Mondiale en Faveur de l'Huile d'Olive. 1. Mémoire. 2. Annexes au Mémoire. (Madrid: Fédération Internationale d'Oléiculture, 1959).

Evaluating Soybeans by Dielectric Analysis and Other Methods. By H. N. Doughty. *Mark, Res. Rep. No.* 367, *U.S. Dep. Agric.* 36 pp. (Washington 25, D.C.: Government Printing Office, 1959). Price 25 *cents.*

Pulp, Paper and Board

Mechanical Pulping Manual. By H. J. Perry *et al. Monogr. Serv. Tech. Ass. Pulp Pap. Ind., N.Y., No.* 21, 1960. 183 pp.

Etudes de Quelques Bois Congolais. By J. R. Istas *et al. Publ. Inst. nat. agron. Congo belge, Sér. tech. No.* 59, 1959. Price 100 *F.* Evaluation of timber species as paper materials.

Rubber

La Présélection des Semenceaux en Heveaculture. (Preselection of Planting Material in Hevea). By E. Evers. *Publ. Inst. nat. agron. Congo belge, Sér. tech. No.* 58, 1959. 62 pp. Price 50 *F.*

Soils

Report of the Macaulay Institute for Soil Research, 1958-59. 52 pp. (Craigiebuckler, Aberdeen: Macaulay Institute for Soil Research).

Soils of Raoul (Sunday) Island. Kermadec Group. By A. C. S. Wright and A. J. Metson. *Soil. Bur. Bull. N.Z., No.* 10. 50 pp. (Wellington: Government Printer, 1959). Price 15*s.*

Soils and Agriculture of Part Geraldine County, New Zealand. By J. D. Raeside *et al. Soil Bur. Bull. No.* 13, *N.Z.* 65 pp. + maps. (Wellington: Government Printer, 1959). Price 17*s.* 6*d.*

The Swamps of Uganda. By L. C. Beadle. *Span*, 1960, **3**, No. 1, 15-17.

Sugar

Proceedings, South African Sugar Technologists' Association, Durban, 16th—20th March 1959. 145 pp. (Mount Edgecombe, Natal: South African Sugar Technologists' Association). Price £1 1*s*. Non-members £1 10*s*.

Report, Bureau of Sugar Experiment Stations, Queensland, 1958-59. 103 pp. (Brisbane: Bureau of Sugar Experiment Stations, 1959).

Studies on the Nematode Soil Fauna of Sugar Cane Fields in Mauritius. 1. The Genus *Monochus*. 2. *Belondiridae*. 3. *Dorylaimidae*. 4. *Tylenchoidea* (*partim*). By J. R. Williams. *Occ. Pap. Mauritius Sug. Ind. Res. Inst. Nos.* 1 2 3 and 4. 13 pp. 9 pp. 28 pp. 30 pp. (Port Louis: Sugar Industry. Research Institute 1958-60).

Proceedings of the Jamaican Association of Sugar Technologists for the Year 1958. *Vol.* 21. 70 pp. (Mandeville P/O: Sugar Research Department). Price 30*s*. or $4.50.

Report Hawaiian Sugar Planters' Association Experiment Station, 1959. 79 pp. (Honolulu: Experiment Station Committee).

Handbook of Cane Sugar Engineering. By E. Hugot. 872 pp. *Publ. Elsevier Publishing Company* 1960.

Tobacco

Tobacco Growing in Australia. By D. W. Goodall. *Rhodesian Tobacco* 1959, No. 20, 15-18.

Production Practices which contribute to Variation in Grades throughout the Plant. By I. Neas. *Rhodesian Tobacco*, 1959, No. 20, 6-7.

Phosphate and Potash Fertilization of Tobacco. By R. C. Salmon and I. McDonald. *Rhodesian Tobacco*, 1959, No. 20, 8-9.

La Planta de Tabaco y el Agua. By E. Alcaraz. *Bol. Inst. Invest. Exp. agron. for., Madr.*, 1959, **19,** No. 41, 175-218. (In Spanish). Moisture control during curing and fermentation.

Estudios sobre la Flora Bacteriana del Tabaco. By A. I. Tamayo and A. de M. Alvarez. *Bol. Inst. Invest. Exp. agron. for., Madr.*, 1959, **19,** No. 41, 363-402. (In Spanish). Microbiology of some Spanish tobaccos.

Weeds and Weedicides

Proceedings of the Fourth British Weed Control Conference, November 4-6, 1958. 271 pp. (London: Society of Chemical Industry, 1960).

Proceedings of the African Weed Control Conference, 23rd-25th July 1958, *Victoria Falls, Southern Rhodesia.* 281 pp. (Chesterford Park Research Station, Saffron Waldron: Fisons Pest Control Limited).

Proceedings, Joint Meeting of the North Central Weed Control Conference (*Sixteenth*) *and the Western Canadian Weed Control Conference* (*Tenth*), *December* 8, 9, 10, 1959, *Winnipeg, Manitoba.* 132 pp. (University of Nebraska, Lincoln: Secretary-Treasurer, North Central Weed Control Conference). Price $4.00.

© *Crown copyright 1960*

Published by
HER MAJESTY'S STATIONERY OFFICE

To be purchased from
York House, Kingsway, London W.C.2
423 Oxford Street, London W.1
13A Castle Street, Edinburgh 2
109 St. Mary Street, Cardiff
39 King Street, Manchester 2
50 Fairfax Street, Bristol 1
2 Edmund Street, Birmingham 3
80 Chichester Street, Belfast 1
or through any bookseller
Price 6*s.* 0*d.* net

Annual Subscription 26*s.* 0*d.* including postage

PRINTED IN ENGLAND UNDER THE AUTHORITY OF HER MAJESTY'S STATIONERY OFFICE BY A. BROWN AND SONS LTD. LONDON AND HULL.

Wt.P8523-K12 Gp. 1215.

A Service in Government Publications

Her Majesty's Stationery Office, publishers of this journal, offer its readers a comprehensive service which will enable them to judge whether any other titles in the vast output of Government Publications would help them in their work or leisure.

Catalogues are published daily, monthly and annually; in the latter two cases, Statutory Instruments are omitted, and separate catalogues for these are published. In addition, numerous sectional catalogues, issued free of charge, list the publications sponsored by individual Government Departments, and in some cases lists covering special subjects are available.

You can obtain full information about this service by sending a postcard to Sales Promotion (HMSO), Room D.42, Atlantic House, Holborn Viaduct, London EC1, asking for our CATALOGUE SERVICE LEAFLET.

Ask at the same time for the name and address of your nearest official agent for Government Publications.

HMSO

Publishers to Her Majesty's Government

PRINTED IN ENGLAND UNDER THE AUTHORITY OF HER MAJESTY'S STATIONERY OFFICE BY A. BROWN AND SONS LTD. LONDON AND HULL.

Wt.P8523-K12 Gp. 1215.

A Service in Government Publications

Her Majesty's Stationery Office, publishers of this journal, offer its readers a comprehensive service which will enable them to judge whether any other titles in the vast output of Government Publications would help them in their work or leisure.

Catalogues are published daily, monthly and annually; in the latter two cases, Statutory Instruments are omitted, and separate catalogues for these are published. In addition, numerous sectional catalogues, issued free of charge, list the publications sponsored by individual Government Departments, and in some cases lists covering special subjects are available.

You can obtain full information about this service by sending a postcard to Sales Promotion (HMSO), Room D.42, Atlantic House, Holborn Viaduct, London EC1, asking for our CATALOGUE SERVICE LEAFLET.

Ask at the same time for the name and address of your nearest official agent for Government Publications.

HMSO

Publishers to Her Majesty's Government

A Selection of Publications on Plant and Animal Products

PREPARED BY THE TROPICAL PRODUCTS INSTITUTE
(FORMERLY THE COLONIAL PRODUCTS LABORATORY)

Obtainable from H. M. Stationery Office

Tropical Science (formerly *Colonial Plant and Animal Products*) Quarterly journal of the Tropical Products Institute.

6*s.* (post 6*d.*) Annual subscription 26*s.*

Obtainable from The Tropical Products Institute

Reprints from *Colonial Plant and Animal Products:*

The Cocoa Processing Industries	1948	9*d.*
The Training of Hide Inspection Officers and Flaying Instructors	1949	1*s.* 6*d.*
Report on the Gum Mastic Industry in Chios	1949	2*s.* 0*d.*
The Preparation of Silk Gut in the British Commonwealth	1950	1*s.* 0*d.*
The Market for Mangoes and Mango Products	1952	1*s.* 6*d.*
The Decortication of Groundnuts	1952	1*s.* 0*d.*
Papain: Its Production and Market	1953	1*s.* 3*d.*
The Luffa Plant and its Uses	1953	1*s.* 3*d.*
Report on Investigations into the Mechanised Production of Jute and Jute Substitute Fibres	1953	2*s.* 0*d.*
The Cultivation and Marketing of Pepper	1953	2*s.* 6*d.*
Stills for Essential Oils	1954	1*s.* 6*d.*
The Production of Cellulose Pulp from Commonwealth Raw Materials	1954	2*s.* 9*d.*
The African Oil Palm	1954	5*s.* 0*d.*
Breeding for Beef in Tropical and Sub-tropical Climates	1954	1*s.* 0*d.*
Plant Ecology as an Aid to Colonial Development	1954	3*s.* 0*d.*
Curing Trials with Sudan Sheep and Goat Skins	1954	2*s.* 0*d.*
A Comparison of the Chemical and Biological Assays of Several Strains of Pyrethrum Flowers	1954	6*d.*
Oils of *Cinnamomum* spp. from Sarawak as a Source of Safrole	1954	9*d.*
The Quality of Groundnuts from the Gambia with Special Reference to Insect Infestation	1954	9*d.*
The Production of Hardboard from Tropical Timbers. I. Kempas (*Koompassia malaccensis*)	1954	2*s.* 0*d.*
The Production of Hardboard from Tropical Timbers. II. Red Meranti (*Shorea leprosula*), Keruing (*Dipterocarpus crinitus*), and Balau (*Shorea laevis*)	1955	2*s.* 0*d.*
The Production of Hardboard from Tropical Timbers. III. African Pencil Cedars (*Juniperus procera* Hochst)	1955	2*s.* 0*d.*
The Genus *Rauwolfia*: Some Aspects of its Botany, Chemistry and Medicinal Uses	1955	1*s.* 9*d.*
Tanning Materials of the British Commonwealth	1955	2*s.* 6*d.*
Sources of Starch in Colonial Territories I. The Sago Palm	1956	3*s.* 2*d.*
Fresh Water from Salt Water: Present Position and Future Prospects	1956	8*d.*
Problems of Quality in Meat	1957	1*s.* 10*d.*
The Chemistry of Some Lesser Known Insecticides	1957	2*s.* 6*d.*

All prices include postage

S.O. Code No. 64-314-60-3*